Status Review of Gila Chub, *Gila intermedia*, in the United States and Mexico

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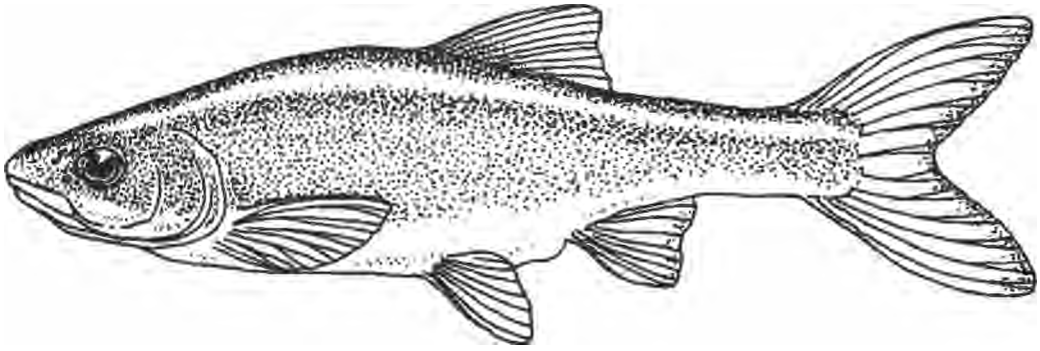

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INTRODUCTION

The Gila chub, *Gila intermedia*, known in Mexico as charalito del Gila, is a member of the minnow family Cyprinidae, and one of five species in the genus endemic to the Colorado River basin. The genus *Gila* is widespread throughout western North America (Hubbs 1940, 1941; Miller 1946). The Gila chub is included on the Arizona Game and Fish Department (AGFD) list of *Wildlife of Special Concern in Arizona* (in prep.), which will replace *Threatened Native Wildlife in Arizona* (AGFD 1988). It was listed in New Mexico as a Group I endangered species in 1975, but is now considered extirpated in that state (Sublette et al. 1990). Although the U.S. Fish and Wildlife Service (FWS or USFWS) no longer maintains a list of candidate species, the Gila chub was also previously a candidate for federal listing as threatened (USFWS 1983).

Comprehensive knowledge about the historic distribution, abundance, life history, taxonomy, current distribution, past declines in abundance and current status of this species is fairly limited. The U.S. Fish and Wildlife Service (FWS) funded this review in order to obtain a summary of the ecology, biology, and past and current distribution of the Gila chub in order to assess the status of this species across its range, as it is currently known. This information is necessary to determine the need for protection and management of the species.

METHODS

MAPPING AND REPORTING METHODS

Abbreviations used used throughout this report for agencies, organizations, projects, programs, and fishes are listed in Appendix A.

Land ownership maps were compiled by Arizona Game and Fish Department (AGFD) Heritage Data Management System (HDMS) specialists, and provided separately in a 97 x 81 cm (38 x 32 in) binder. Maps were constructed only for streams suspected or known to contain Gila chubs. Maps were not produced for sites where the Gila chub was known to be extirpated prior to this review. End points for each stream reach were selected in an attempt to include all possible perennial flow or suspected distribution of Gila chubs based on our best estimates. Each map contains land ownership status and area (in acres) for a buffer zone of one mile on either side of the selected reach. Land ownership statistics were calculated by HDMS, based on the Arizona State Land Department (ASLD) land ownership database. Township, range, and section lines and 7.5' quadrangle map names were included (when available) on the maps to aid in accurate location of sample sites. Information available from ASLD on mine locations was also included on each map to help identify land uses.

observed in the areas surveyed. Also measured were water temperature, pH, conductivity, and dissolved oxygen. Sample site photographs are on file with AGFD, Native Fish Program.

A sub-sample of *Gila* from each collection locality was preserved as voucher specimens and accessioned into the ASU Museum of Fishes. For all *Gila* preserved, measurements of head length (hl) and least depth of caudal peduncle (pd) were taken with Vernier calipers. Measurements were taken as soon as possible following preservation to minimize effects of specimen shrinkage. An hl/cp ratio was calculated (Minckley 1973). Meristic counts (dorsal and anal fm rays and lateral line scales) followed conventions in Hubbs and Lagler (1958).

METHODS USED TO DESCRIBE POPULATION STATUS

Based on their current status, Gila chub populations were placed into one of four categories. Due to a general lack of quantitative data, qualitative measures were used as follows:

Stable-Secure	Gila chubs are common, data over last 5-10 years show a stable reproducing population, no impacts from nonnatives (predatory species), no current or future land use threats were identified.
Stable-Threatened	Gila chubs are common to uncommon, potential threats by nonnatives exist, some habitat altering land and water uses were identified, or lack of recruitment was detected within the population.
Unstable-Threatened	Gila chubs are rare, have limited distribution, predatory or competitive nonnatives are present, or habitat modified or threatened.
Extirpated	Gila chubs are no longer found within the system.
Unknown	Lack of data precludes determination of status.

RESULTS

TAXONOMY

Baird and Girard (1854:28) published the original description for Gila chub as *Gila gibbosa.* Following the original description, several generic and specific names were applied over the years to the species, making for a chaotic nomenclatural history:

widely divergent and each possesses many morphologically uniform populations; 2) the geographic distributions of both species is an overlapping mosaic, therefore subspecies status for *G. intennedia* is inappropriate under traditional geographic criteria; and 3) contiguous populations of *G. intermedia* and *G. robusta* show no evidence of ongoing genetic exchange, and maintain their evolutionary independence. DeMarais (1986, 1992) elaborates on these findings.

Contrary to Rinne's (1969, 1976) designation of *G. r. grahami* populations, DeMarais (1986, 1992, 1995) identified those populations as being phenotypically intermediate between *G. robusta* and *G. intermedia* and the result of ancient introgressive hybridization between the two. Although Dowling and DeMarais (1993) documented the widespread occurrence of ancient hybridization among several other *Gila* species, DeMarais (1995) stated that the identification of molecular characters from *G. intermedia, G. robusta,* and phenotypically intermediate populations *(G. r. grahami)* neither supports nor refutes the hybrid origin of *G. r. grahami.* DeMarais (1995) did not support recognition of *G. r. grahami as* a valid taxon, and recommends that they be referred to as *G. robusta.* A more accurate, and perhaps more appropriate, way of discussing *G. r. grahami* populations is to refer to them as phenotypically intermediate between *G. robusta* and *G. intennedia.* Thus, populations of *Gila* formerly designated as *G. r. grahami* or those which were formerly found to exhibit phenotypic characteristics intermediate between ***G. intermedia*** and *G. robusta* are now considered to be roundtail chub, *Gila robusta,* for the purposes of this report, but may still be referred to as "grahami" when discussing previous reports or collections. Phenotypic intermediates inhabit the middle and upper Gila River basin. A summary of taxonomic nomenclature assigned to populations of "grahami" by several authors and museums and nomenclature followed in this report is provided in Table 1.

HISTORIC DISTRIBUTION

Gila species are known from mid-Miocene to present (Miller 1965; Uyeno and Miller 1965; Lugaski 1977; Smith and Miller 1986). Species similar, if not identical to, roundtail chub *(Gila robusta,* Baird and Girard 1853a) were present in late Pliocene (Uyeno and Miller 1963, 1965). Probable evolutionary events involve 1) habitation of the lower Colorado River basin by a form of *G. robusta* (possibly "grahami") derived from the north in early stages of drainage integration with the Colorado Plateau, 2) invasion of a second form of *Gila (G. intermedia* or its ancestor) from the south and habitation of waters south and west of the Mogollon Highlands, 3) completion of internal integration of the Gila basin allowing invasion of an aggressive, larger-river population of *G. robusta* into areas inhabited by the previously mentioned chubs, and 4) the occurrence of ecological adjustments and displacements, plus intergradation of the two forms of *G. robusta,* until complementary distributions were attained (Rinne 1969).

The Gila chub's historic range likely included suitable habitat throughout the entire Gila River basin (Minckley 1973; Sublette et al. 1990), except the Salt River drainage above Roosevelt Lake (DeMarais 1995). To date, Gila chubs have been recorded in approximately 30 rivers, streams, and spring-fed tributaries throughout the Gila River basin in New Mexico, northern Sonora, Mexico, and central and southeastern Arizona (Miller and Lowe 1967; Rinne and Minckley 1970; Minckley 1973; Rinne 1976; DeMarais 1986; Bestgen and Propst 1989).

In Arizona, Gila chubs are known to have inhabited tributaries of the Gila river including main stem or tributaries of the Salt, Verde, Santa Cruz, San Pedro, San Simon, San Francisco, and Agua Fria river drainages (Fig. 1). Occupied habitats included suitable cienegas and small tributaries (Minckley 1969; Stout et al. 1970), and artificial habitats such as the Buckeye Canal (Rinne 1969). The northernmost documented location was in the upper Verde River system below the Mogollon Rim, in Big Chino Wash and Williamson Valley Wash (Rinne 1969, 1976).

A strong correlation exists between the historic distribution of cienega habitats (see Hendrickson and Minckley 1984) and the known distribution of Gila chubs in the San Pedro, Santa Cruz. and San Simon River basins. Loss of many of those habitats, due to arroyo cutting in the late 1800s and early 1900s, likely resulted in loss of undocumented Gila chub populations.

In western New Mexico, the species formerly inhabited the Gila River basin in Apache Creek, Catron County; Duck Creek, Grant County; and San Simon Cienega, Hidalgo County (Rinne 1969, 1976; Hubbard et al. 1979; Bestgen and Propst 1989; Sublette et al. 1990). Gila chubs were collected in the San Francisco River, New Mexico in 1872, but the exact location remains unknown (Sublette et al. 1990).

Gila chubs likely inhabited the San Pedro River headwaters and the Santa Cruz River in northern Sonora, Mexico. J.H. Clark's collection, in 1851, of the type specimen in the Rio Santa Cruz occurred in what is now Sonora (Varela-Romero et al. 1992). However, no other published historic records (pre-1990) indicate Gila chub presence in Mexico. In August 1990, Gila chubs were discovered in Mexico at Cienega los Fresnos, a tributary to the San Pedro River, in Sonora, Mexico (Varela-Romero et al. 1992). Gila chubs were collected again from Cienega los Fresnos in 1991. During that survey they were also collected from Cienega la Cienegita (Gori 1993). Both populations were associated with spring-fed cienegas isolated from the San Pedro River by extensive dry stretches of stream.

DeMarais (1995) stated that *G. intennedia* might occur in the upper Bill Williams drainage. Relatively gentle divides separate it from streams of the upper Verde River; *G. intennedia* could be transferred via stream capture. Extant or recent populations of Gila chubs in extreme headwaters of the Verde (Williamson and Chino Valleys) document the potential for natural transfer into the Bill Williams system. Occurrence in the Bill Williams of characteristic Gila basin species such as longfin dace *(Agosia chrysogaster)*, Gila sucker *(Catostomus insignis),* and Gila mountain sucker *(Pantosteus clarki)* may reflect such a phenomenon.

LIFE HISTORY

Description of the Species

The Gila chub is small-finned, deep-bodied, chubby (chunky), and darkly colored (sometimes lighter on belly; diffuse lateral band(s) are rarely present). Adult males average about 150 mm (6 in) in total length; females can exceed 200 mm (8 in). Scales are coarse, large, thick, and broadly imbricate, with basal radii typically present. Lateral-line scales usually number greater than 61 and less than 80. There are usually eight (rarely seven or nine) dorsal and anal fin-rays; pelvic fin-rays typically number eight, but sometimes nine. Head length divided by caudal peduncle depth is 3.0 or less. An abrupt, soft and fatty nuchal hump rarely develops in large females of some populations. Total number of vertebrae ranges between 38 and 45 (usually fewer than 42). Barbels are absent. The pharyngeal arch is similar to *G. robusta,* with teeth in two rows (2, 5-4, 2 with some variation). Both sexes possess breeding tubercles, although distribution is less extensive in females. There is no basicaudal spot (Rinne 1969, 1976; Minckley 1969, 1973; DeMarais 1986).

Descriptions for roundtail chub, both *G. r. robusta* and "grahami", are included for comparison:

> The roundtail chub has a thick (not chubby), less robust body, with light to mottled coloration. Adult body length is highly variable, but typically ranges from 250 to 350 mm (10-14 in). The species is larger-finned than the Gila chub, and its scales are smaller, thinner, and slightly imbricate. Basal radii are absent to weakly developed. Lateral-line scales usually number more than 80. Dorsal, anal, and pelvic fin-rays usually number nine. Head length divided by caudal peduncle depth is usually 3.3 to 4.3, but rarely greater than 4.0. A fatty nuchal hump is rarely developed, and if present, scarcely discernible. Total vertebrae range from 43 to 49 (Winn and Miller 1954; Rinne 1969).
>
> The morphologically intermediate "grahami" is relatively thick bodied, dark, gray, and commonly shows coloration blotches on dorsal and lateral areas. There are 70 to 90 lateral-line scales (usually 75 to 85); eight or nine anal fin-rays; and a mean head length divided by mean caudal peduncle depth almost always less than 3.3 (Rinne 1976).

Meristic and morphometric correlations suggest the use of one or two characters, dorsal fin-ray counts or ratio of head length to caudal peduncle depth, is adequate to distinguish *G. intermedia* from *G. robusta* (DeMarais 1995). Additional characters are unlikely to greatly aid identification. Identification in the field may therefore be possible, and nearly as accurate as a more detailed analysis. However, keys developed by Rinne (1969) and DeMarais (1986) are based on mean measurements within a population; a sufficient sample size is necessary to accurately identify the range of variation within the population. Identification of individual specimens will remain problematic. Table 2 compares morphometric measurements and meristic counts for *G. intermedia*, *G. robusta,* and phenotypic intermediates.

Ecology

The biology of this species is poorly understood. Current knowledge is gathered from specific populations, but species variation demands further research using a broader sampling base. *Gila intermedia* is morphologically and morphometrically similar to *G. robusta.* Gilbert and Scofield (1898) indicated local sympatry occurred between *G. intennedia* and at least one other *Gila* species in complex Arizona habitats from the Salt River in the Tempe area. Although *Gila* species are reported as existing in habitat separated by only tens of meters, there are no collection records of *G. intermedia* and other *Gila* species at the same location (Rinne 1969; Minckley 1973, 1985; DeMarais 1986).

Native fishes that have occurred throughout historic range of Gila chub include roundtail chub, loach minnow *(Tiaroga cobitis),* spikedace *(Meda fulgida),* speckled dace *(Rhinichthys osculus),* longfin dace, Sonora sucker, desert sucker, desert pupfish *(Cyprinodon macularius),* and Gila topminnow *(Poeciliopsis o. occidentalis).* Other fishes collected from the Gila River basin that may have been present with transient populations of Gila chubs in larger riverine habitats include: woundfin *(Plagopterus argentissimus),* bonytail chub *(Gila elegans),* squawfish (*Ptychocheilus lucius),* flannelmouth sucker *(Catostomus latipinnis),* and razorback sucker *(Xyrauchen texanus).* Yaqui catfish *(ktalurus pricei)* was introduced into Gila chub habitat at Monkey Spring, presumably from the Rio Sonora basin in Sonora, Mexico (Minckley 1973).

Nonnative fishes known from within historic range of Gila chub in the Gila River basin include channel catfish *(ktalurus punctatus),* flathead catfish *(Pylodictis olivaris),* red shiner *(Cyprinella lutrensis),* fathead minnow *(Pimephales promelas),* green sunfish *(Lepomis cyanellus),* largemouth bass *(Micropterus salmoides),* smallmouth bass *(Micropterus dolomieui),* rainbow trout *(Oncorhynchus mykiss),* mosquitofish *(Gambusia affinis),* and carp *(Cyprinus carpio)* (USFWS 1983; Dunsmoor 1993; Young and Bettaso 1994). Other nonnatives collected within the range of Gila chubs include: warmouth *(Lepomis gulosus),* bluegill *(Lepomis macrochirus).* yellow bullhead *(Ameiurus natalis),* black bullhead *(Ameiurus melas),* and goldfish *(Carassius auratus)* (AGFD Native Fish Database [NFDB]).

Habitat

Gila chubs commonly inhabit pools in smaller streams, cienegas, and artificial impoundments throughout its range (Miller 1946; Minckley 1973; Rinne 1975). Habitats occupied by populations of Gila chubs exhibit unique physico-chemical characteristics, riparian types, and seasonal parameters (USFWS 1983; Vives 1990). Common riparian plants associated with these populations include willows *(Salix* spp.), tamarisk *(Tamarix* spp.), cottonwoods *(Populus* spp.), seep-willow *(Baccharis glutinosa),* and ash *(Fraxinus* spp.). Typical aquatic vegetation includes watercress *(Nasturtium officianale),* horsetail *(Equisetum* spp.), rushes *(Juncus* spp.), and speedwell *(Veronica anagallis-aquatica)* (Goodwin 1979; USFWS 1983).

Nelson (1993) attempted to identify cover and substrate types, duration of spawning, breeding color changes, and water temperature during spawning in Cienega Creek, Arizona. Intensely colored Gila chubs averaging 163 mm (6.5 in) total length were captured when water temperatures were warmer than 17 C (62°F). Moderately colored fish averaging 93 mm (3.7 in) total length were captured in water temperatures from 13 to 24°C (55 to 75°F). Slightly colored fish averaged 95 mm (3.8 in) total length and fish displaying no color averaged 73 mm (2.9 in) total length. Intensely, moderately, slightly, and no coloration were present in 23.8 percent, 19.6 percent, 20.3 percent, and 36.4 percent of the fish sampled, respectively. Data suggest that individuals greater than 75 to 80 mm (3.0-3.2 in) total length could participate in spawning. Nelson (1993) concluded that warmer water temperatures (20 to 24° C [68 to 75° F]) appear to increase breeding color intensities.

Growth

Gila species typically display sexual dimorphism, with females usually attaining larger sizes than their male counterparts (Minckley 1969, 1973). Female Gila chubs can reach 250 mm (10 in) in total length, but males rarely exceed 150 mm (6 in) (Rinne and Minckley 1991). This complicates age and growth analysis. The now extinct Monkey Spring population displayed unusual growth patterns with much larger scales, marked size disparity between sexes with males being much smaller, and other body feature differences.

Griffith and Tiersch (1989) examined scales of Gila chubs from Redfield Canyon, Arizona to determine age class structure. The chubs displayed rapidly accelerating growth. Fifty-one percent of yearling scales showed new growth. However, no older fish displayed new growth. During the first year, the chubs laid down an average of 14.8 circuli (range of 9-23). Scale analysis indicated four age groups comprised the population. Back calculation indicated average total lengths were 90 mm (3.6 in), 135 mm (5.4 in), 160 mm (6.4 in), and 183 mm (7.3 in) after the first through fourth years of life, respectively. Total range of fish examined was 45-222 mm (1.8-8.9 in) total length (n=113). Annual growth declined rapidly after the first year.

Foods and Feeding Habits

Griffith and Tiersch (1989) observed that Gila chubs are omnivorous. Adults appear to be principally carnivorous, feeding on large and small aquatic and terrestrial invertebrates and sometimes other small fishes (Rinne and Minckley 1991). Smaller individuals often feed on organic debris and aquatic plants (especially filamentous algae), and less intensely on diatoms. Adults usually move and feed more during evening and early morning, while young are active throughout the day (Rinne and Minckley 1970; Minckley 1973; Griffith and Tiersch 1989).

No true stomach is present, and there is a one-to-one ratio of gastrointestinal tract length to fish body length (Griffith and Tiersch 1989). Griffith and Tiersch (1989) dissected 27 Gila chub stomachs from Redfield Canyon, finding aquatic material that included speckled dace and

Table 3. Miscellaneous SMNH and UMMZ museum collections from Arizona. These collections are either not considered Gila intermedia, or are from populations not included in stream-specific discussions. The species identification reported is taken directly from the identified museum's records. Date is presented as year month day.

Date	Source	Id. as reported by Museum	Collector	Descriptive Location	Other Species
(18)880416	SMNH 39576	GIROIN	Mearns	Verde River, Fort Verde	CAIN
040408	SMNH 130023	GIROIN	Chamberlain	Cienega Spring, 9 mi SW of Safford	
040420	SMNH 130007	GIROIN	Chamberlain	Tonto Creek, Howell's	PACL CAIN AGCH
040422	SMNH 130017	GIROIN	Chamberlain	Fossil Creek, Strawberry, in Yavapai Co.	PACL RHOS
040423	SMNH 130020	GIROIN	Chamberlain	East Verde Creek, Angora, 5 mi N of Payson	PACL RHOS
040425	SMNH 130010	GIROIN	Chamberlain	Tonto Creek at Roosevelt	CAIN AGCH
040425	SMNH 143138	GIROIN	Chamberlain	Salt River, Roosevelt, Maricopa Co.	PACL CAIN CALA AGCH CYCA GIRO PTLU MEFU POOC
260916	UMMZ 94886	intergrade GIROxGIIN	Not available	East Verde River, N Of Payson	PACL RHOS
290419	SMNH 107219	GIROIN	Myers	Gila River, below Gillespie Dam	AGCH POOC
370427	UMMZ 120101	intergrade GIROxGIIN	Jackson	Beaver Creek, above Montezuma Castle, 14N 5E	PACL CAIN
370609	UMMZ 120088	intergrade GIROxGIIN	Tarzwell, Gee	Fossil Creek, @ x-ing below power house	PACL
370617	UMMZ 121660	intergrade GIROxGIIN	Not available	Black River, East Fork- @ Buffalo Crossing	PACL CAIN RHOS
370623	UMMZ 121651	intergrade GIROxGIIN	Not available	Black River, East Fork- @ Three Forks	RHOS
371013	UMMZ 131102	intergrade GIROxGIIN	Tarzwell, Gee	Tonto Creek, below mouth of Christopher Creek	RHOS PACL
430509	UMMZ 146666	intergrade GIROxGIIN	Not available	Gila River, 1 mi below Winkelman	GAAF PACL CAIN POOC AGCH

Agua Fria River Basin

Indian Creek

Site Description
Indian Creek, Yavapai County, Arizona is a tributary of the Agua Fria River. It flows in a westerly direction, originating along the western slopes of 22 Mesa, west of the Verde Rim at an elevation of 1420 m (4680 ft). It terminates at the confluence with the Agua Fria at an elevation of 1000 m (3280 ft). Indian Creek is ephemeral from its headwaters to the Prescott National Forest Boundary where it becomes perennial for approximately the next 6.4 km (4 mi). The remaining 3.2 km (2 mi) above the Agua Fria River is essentially subsurface.

Land Ownership
Land ownership within a 1.6 km (1.0 mi) buffer around Indian Creek, beginning at its confluence with the Agua Fria River and continuing 24.9 km (15.5 mi) upstream is comprised of BLM (59%), Prescott National Forest (39%), and private (2%) lands (Indian Creek Land Ownership Map). Private lands are located at the confluence with the Agua Fria River and at a small inholding several miles upstream of the confluence.

Land and Water Uses
Land and water uses on the private lands are unknown. BLM and National Forest lands are primarily used for cattle grazing.

Collection History
Gila chubs were not known from Indian Creek until May 1995, when they were collected from a site approximately 1.6 km (1.0 mi) downstream of the Prescott National Forest Boundary (Table C-1). Associated species included longfin dace and desert sucker. Prior to that collection, Fall Fish Count (FFC) surveys conducted by BLM biologists at two locations (T11N R3E, Section 26 and 34) over three years reported collecting only longfin dace and desert sucker. These two locations were approximately 1.6 km (1.0 mi) and 3.2 km (2.0 mi) below where chub were found in 1995. BLM and AGFD had proposed introducing Gila chubs into Indian Creek prior to the discovery of this population.

Recent Survey Results
Indian Creek was not surveyed for this project due to information available from previous FFC surveys and the survey of May 1995 conducted by Dan Langhorst of the BLM. At that time, Gila chubs (n=18) were found to comprise 29 percent of the fish fauna.

Status, Threats, and Management Recommendations
Unstable-Threatened. Lack of historical distribution and abundance data precludes determining decreases in this population's distribution. However, due to absence from previous surveys (Fall of 1992, 1993, and 1994) downstream of the May 1995 survey site, it is reasonable to conclude

Status, Threats, and Management Recommendations

Stable-Threatened. The Gila chub is generally a common component of the fish community within Silver Creek. Green sunfish are generally collected within areas also occupied by Gila chubs below the waterfall. The presence of a waterfall fish barrier, approximately 4 km (2.5 mi) above the Agua Fria River confluence, undoubtedly has forestalled any major conflicts between Gila chubs and nonnative fishes above the barrier. Periodic surveys should be initiated to monitor the Gila chub status and to evaluate continued effectiveness of the fish barrier.

Sycamore Creek

Site Description

Sycamore Creek, Yavapai County, Arizona is a tributary of the Agua Fria River. It originates at Pine Springs in the Black Hills, within the Pine Mountain Wilderness Area on the western side of the Verde Rim. The creek runs approximately 32 km (20 mi) in a southwesterly direction to the Agua Fria River. Elevations along the stream range from about 1790 m (5880 ft) at the headwaters to roughly 1070 m (3520 ft) at its confluence with the Agua Fria River. The stream is perennial throughout most of its length; the lower 3 km (2 mi) are ephemeral.

Land Ownership

Land ownership within a 1.6 km (1.0 mi) buffer beginning at the confluence with the Agua Fria River and continuing 29.2 km (18.2 mi) upstream is comprised of Prescott National Forest (59%), **BLM (27%), private (12%), and State Trust (3%) lands (Sycamore Creek Land Ownership Map).**

Land and Water Uses

Land and water uses on the private lands are primarily those associated with cattle grazing and residences. **BLM and State Trust land uses** are dominated by cattle grazing. Cattle grazing and recreational activities are the principle uses on Prescott National Forest lands.

Collection History

The earliest collection of Gila chub on record is two miles southeast of Dugas in May 1930 (Table C-3). These fish were originally recorded as *G. robusta,* **but later identified as** *G. intermedia,* (DeMarais 1986). Several other collections from ASU are reported as roundtail **chub, but are believed to be Gila chub. Subsequent surveys also recorded Gila chubs from Sycamore Creek (most recent in April 1995). FFC surveys conducted in 1990, 1991, 1993, and 1994 by BLM biologists at a site 5 km (3 mi) below Dugas (T11N R3E, Section 11, SW4) failed to collect Gila chubs (Table 4). AGFD, as part of a cost share agreement with Prescott National Forest, conducted surveys of Sycamore Creek within Prescott National Forest in April 1995. Nine sites were surveyed, and three of the nine locations supported Gila chubs (Table 5).**

of Rock Bottom Box, longfin dace, green sunfish, desert suckers, speckled dace, and fathead minnows were collected; rainbow trout and Gila chubs were conspicuously absent.

Recent Survey Results

Sycamore Creek was not surveyed for this project due to information available from a number of previous surveys, including that conducted by AGFD in April 1995 (Bettaso et al. 1995).

Status, Threats, and Management Recommendations

Stable-Threatened. The presence of the barrier at Rock Bottom Box undoubtedly has served to forestall any upstream movement of nonnative fish, while Double T Falls has effectively blocked Gila chubs from invading the upper-most sections of Sycamore Creek. The rainbow trout found in the upper sections are purportedly the descendants of 2,000 juvenile rainbow trout stocked into upper Sycamore Creek on April 10, 1942 (Bettaso et al. 1995). With the integrity of the Rock Bottom Box barrier maintained, it is unlikely that additional nonnative fishes will become a management concern, at least within the upper sections of the creek, unless they are moved by people. Overuse of riparian galleries and the upland watershed by livestock, along with impacts by recreational users along the lower stretches of the creek, does represent a potential threat to the long term health of this stream.

Information from historical collections is inadequate to determine past distribution or declines in distribution or abundance. Collection of Gila chubs in 1979 at the USFS Administration site and subsequent failure to collect them during FFC surveys in 1990-1994 indicate the lower portion of Sycamore Creek may no longer be occupied. Gila chubs are currently known to occupy only about 5 km (3 mi) of Sycamore Creek. Not all of the the 29.2 km (18.2 mi) of Sycamore Creek delineated on the Land Ownership map is perennial.

Little Sycamore Creek

Site Description

Little Sycamore Creek, Yavapai County, Arizona is a tributary of Sycamore Creek, originating at the confluence of several unnamed streams flowing from Chalk Tank Canyon, Rock Spring Draw, and Willow Spring at an elevation of 1290 m (4240 ft). Little Sycamore Creek flows in a westerly direction approximately 5 km (3 mi) to its confluence with Sycamore Creek, near Dugas, at an elevation of 1210 m (3960 ft). The stream is ephemeral throughout most of its length. Perennial water is present for 0.8 km (0.5 mi) above the confluence with Sycamore Creek, and for about 0.4 km (0.25 mi) at a spring above Horner Mountain Ranch. Above Horner Mountain Ranch, the flow becomes subsurface, leaving only a few isolated pools present within the stream channel.

Land Ownership

A Land Ownership Map was not produced for this stream as Gila chubs are extirpated from it (Rinne 1975). Approximately 2.4 km (1.5 mi) of Cave Creek are privately owned, with the remainder managed by the USFS Tonto National Forest.

Land and Water Uses

The Cartwright Ranch maintains a collection box and irrigation canal in Seven Springs Wash to convey water for a pond and pastures. The remainder of spring flow continues through the Cave Creek/Seven Springs Campground and down Cave Creek. USFS lands along Cave Creek are subject to multiple uses as mandated by Federal law and may be grazed, mined or provide for recreational opportunities. Cattle, cattle sign, hiking, and other signs of recreation were frequently observed in 1992 (Young and Bettaso 1994). A USFS campground is present at the confluence of Seven Springs Wash and Cave Creek, and a hiking trail follows Cave Creek downstream from this point. Roads in the area have several concrete stream crossings that likely serve as barriers to upstream movement of fish under most flow regimes, but the potential for transport by people is high.

Collection History

Gila chubs were first collected by Miller and Winn in 1950 (Table C-5). They were subsequently collected through 1978. Stout et al. (1970) found Gila chubs comprised 12 percent of all fish collected in Seven Springs, but did not find them at eight other sample locations downstream in Cave Creek. Several age classes were present and the population was considered reproductively active as determined by presence of small specimens. Rinne (1975) reported Gila chubs predominantly restricted to the headspring pool of Seven Springs in 1970 and exclusively restricted to the headspring pool in 1971. Stout et al. (1970) found them throughout Seven Springs Wash. Seven Springs was renovated in 1970 and 1971 in attempts to establish populations of spikedace and loach minnow (Rinne 1975). Rinne (1975) reported collecting five specimens of Gila chub in the Seven Springs Wash headspring in summer 1971, but failed to collect any in May 1973. Stefferud (1992) reported that Gila chubs have not been collected in the Cave Creek drainage since 1971. However, Clarkson collected Gila chubs from Cave Creek near the campground in 1978 (ASU collection #7764). Clarkson also surveyed Seven Springs in 1979 and reported collecting only longfin dace (Bancroft et al. 1980).

Annual monitoring of Cave Creek and/or Seven Springs by AGFD biologists as part of the Gila topminnow reintroduction program occurred in 1985 to 1987, 1989, and 1991 to 1995 (AGFD NFDB). No chub were collected during these efforts, however most surveys were conducted using dipnets and seines, which may have been less effective at capturing Gila chubs.

As a result of a Biological Opinion issued by the FWS on the Quien Sabe prescribed burn, the USFS Tonto National Forest was required to conduct monitoring in Cave Creek and Seven Springs. Monthly monitoring conducted April through December 1992 (except September) at three sites resulted in the capture of 4,709 longfin dace, 1,122 fathead minnows, and 2,187 Gila

Land and Water Uses
Land and water uses in the vicinity of Fish Creek are primarily associated with recreation (i.e. camping, hiking, and fishing), although grazing is likely occurring within the watershed.

Collection History
The earliest reported collection of Gila chub (reported as *G. robusta)* was in October of 1963 by W. L. Minckley (Table C-6). A second collection (again recorded as *G. robusta)* was made in October of 1965 by W. L. Minckley. Both collection localities were reported simply as Fish Creek, northeast of Tortilla Flat. Those specimens were later identified as *G. intermedia* (Rinne 1969; DeMarais 1986). No subsequent collections of Gila chubs have been made. A survey conducted by AGFD for this project in June 1993, from the Arizona Highway 88 bridge upstream to the confluence with Little Goat Canyon, found only longfin dace.

Status, Threats, and Management Recommendations
Extirpated. The Gila chub is considered extirpated from Fish Creek. Information on the distribution and abundance of Gila chubs in Fish Creek is inadequate to determine the amount of Gila chub range lost. Surveys by AGFD in 1993 did not address suitability of Fish Creek for reintroduction of Gila chub, but that should be investigated in the future.

Rye Creek

Site Description
Rye Creek is a first order tributary to Tonto Creek, Gila County, Arizona. Its headwaters are **in** the Mazatzal Mountains of central Arizona near an elevation of 1220 m (4000 ft). It joins Tonto Creek south of Gisela near 820 m (2700 ft).

Land Ownership
Land ownership within a 1.6 km (1 mi) buffer beginning at the confluence with Tonto Creek and continuing upstream 15.5 km (9.6 mi) is comprised of Tonto National Forest (93%) and private (7%) lands. Although a majority of the land is Federally owned, private lands are found mostly along the stream course.

Land and Water Uses
Tonto National Forest Lands are open to cattle grazing, recreation, and other uses as allowed by the Land Management plan developed under the National Forest Management Act. During surveys in 1995, no water diversions, pumping, or wells were observed within Rye Creek. Several small ranches are along the creek. Cattle grazing was observed near the confluence with Tonto Creek and also above the Highway 87 bridge, an area that is not perennial. According to the Land Ownership Map, there are numerous mines within the watershed, but it is not known whether or not they are active.

the *G. intennedia* phenotype, in particular exhibiting only eight dorsal fm rays (a defining character of *G. intermedia*). Sample sizes are too small to statistically validate this observation. We consider this population to be *G. robusta,* similar to Tonto Creek *Gila,* although more closely approaching the Gila chub phenotype.

The first recorded presence of smallmouth bass in Rye Creek was in 1995. They were previously encountered in Tonto Creek, and may have invaded naturally or by human assistance. In combination with the limited habitat available in Rye Creek, smallmouth bass pose a serious threat to the chubs in Rye Creek, regardless of taxonomic identity.

Verde River Basin

Woods Canyon and Rattlesnake Canyon, tributaries to Beaver Creek, Mullican Canyon, tributary to Red Tank Draw, and sites within Dry Beaver Creek were surveyed in 1995 for the Coconino National Forest in association with this project. No Gila chub were collected from any of the sites surveyed. A separate report summarizing these activities is available.

Walker Creek

Site Description
Walker Creek is a tributary of Wet Beaver Creek in Yavapai County, Arizona. It runs north and west from an elevation of 1710 m (5600 ft) on Walker Mountain down to 1200 m (3600 ft) at the confluence with Wet Beaver Creek. The lower 1.6 to 3.2 km (1 to 2 mi) is ephemeral and perennial water is present from there upstream about 4.8 km (3 mi) to just below the confluence with Spring Creek.

Land Ownership
Land ownership within a 1.6 km (1 mi) buffer along Walker Creek beginning near its confluence with Wet Beaver Creek and continuing upstream for 11.3 km (7.0 mi) is comprised of Coconino National Forest (93%), ASLD (6%), and National Park Service, Montezuma Well National Monument (1%) lands (Walker Creek Land Ownership Map).

Land and Water Uses
The lower and upper 1.6 to 3.2 km (1 to 2 mi) of stream are open to grazing on USFS lands. **The** middle stream reach is confined in a steep canyon, inaccessible to cattle. Forest Road 618 crosses Walker Creek about 1.6 km (1.0 mi) upstream from Wet Beaver Creek. Dispersed recreation (hiking and backpacking) and cattle grazing are predominant land uses within the watershed.

Land Ownership
Lands within Red Tank Draw watershed are owned and managed by USFS, Coconino National Forest. Private lands are also identified on the USFS Coconino National Forest map near the confluence with Wet Beaver Creek. No land ownership map was produced for this stream.

Land and Water Uses
Land and water uses within Red Tank Draw are those associated with the multiple use mandate of the USFS. There are no known diversions or withdrawals of water from Red Tank Draw. The U.S. Geological Survey maintains a gaging station in the mid-reach of the stream.

Collection History
On October 14, 1995 Red Tank Draw was sampled by Department biologists and volunteers for this project. Green sunfish and Gila chubs were collected from pools above and below the crossing of Forest Road 618. Two chub specimens were preserved. It was sampled again in December, 1995, in an attempt to capture more large specimens of Gila chub for identification. Thirty two chubs were captured, two were preserved and thirty released. The released chub were considered too small to get accurate meristic counts. Several hundred small to medium sized green sunfish were also collected incidental to those efforts.

The results of selected meristic counts and morphometric measurements from those specimens is presented in Table 7. The results of these counts and measurements indicate that the specimens are Gila chubs. The discovery of this population delivers hope that there are more undiscovered populations of Gila chub present within the Verde River basin. All specimens were submitted to the ASU Museum of Fishes.

Status, Threats, and Management Recommendations
Unknown. Red Tank Draw should be the focus of more intensive surveys to determine range of distribution and abundance. Additional specimens should be collected and subjected to detailed morphometric and genetic analysis to verify the identity of these chubs.

Oak Creek

Site Description
Oak Creek is a tributary of the Verde River in Yavapai and Coconino counties, Arizona. It flows south from the Mogollon Rim near Flagstaff at an elevation of about 2190 m (7200 ft) to its confluence with the Verde River at 970 m (3,170 ft). Three AGFD hatcheries operate within the Oak Creek drainage: Page Springs, Bubbling Ponds, and Sterling Springs hatcheries.

Land Ownership
Land ownership within a 1.6 km (1 mi) buffer of Oak Creek from the Verde River confluence upstream 80.6 km (50.6 mi) to Sterling Springs Hatchery is comprised of Coconino National Forest (69%), private (27%), State (2%), Coconino County (1%), AGFD (<1%), and Prescott

Although there have been no recent collections of Gila chubs from the mainstream of Oak Creek, Gila chubs presently occur in Spring Creek, a small, low-gradient tributary near the town of Page Springs (AGFD NFDB). Gila chubs are abundant in Spring Creek, but they have never been found immediately downstream at the confluence with Oak Creek, even though no physical barrier exists which would preclude their movement. Gila chubs must, on rare occasions, reach Oak Creek from Spring Creek or other tributaries. Therefore, collection of Gila chubs in Oak Creek would not be entirely unexpected.

Recent Survey Results
Oak Creek was not surveyed for this project.

Status, Threats, and Management Recommendations
Oak Creek was not given a status ranking. Whether *G. intermedia* at one time maintained a self-reproducing population in Oak Creek is unknown, but it seems unlikely for a variety of reasons. First, *G. robusta* (possibly a phenotypically intermediate population) occurs in Oak Creek (Minckley 1973). Second, most reaches of the relatively large and steeply graded Oak Creek are more characteristic of *G. robusta* habitat than of *G. intennedia.* Lower gradient, marshy stretches, if present, could provide habitat for Gila chubs. We feel that Oak Creek contains roundtail chubs, although Gila chubs may occasionally be found in Oak Creek as a result of active or passive dispersal from Spring Creek.

Spring Creek

Site Description
Spring Creek is a tributary of Oak Creek in Yavapai County, Arizona. It flows south near Casner Mountain at an elevation of 1830 m (6000 ft) approximately 26 km (16 mi) to its confluence with Oak Creek at 1020 m (3340 ft) in elevation. The entire upper 21.1 km (13.1 mi) are ephemeral and surface flow begins approximately 3.2 km (2 mi) above the confluence.

Land Ownership
Land ownership within a 1.6 km (1.0 mi) buffer along Spring Creek beginning at the Oak Creek confluence and continuing upstream 21.1 km (13.1 mi) is comprised of Coconino National Forest (73%), State (14%), private (12%), and AGFD (< 1%) lands (Spring Creek Land Ownership Map). A large majority of the land along the known perennial reach of Spring Creek, 3.2 km (2 mi) is private.

Land and Water Uses
Spring Creek is dry throughout its upper reach and becomes perennial shortly upstream from the crossing of Forest Road 796 at a spring in T18N R4E, Section 22, NE4. The upper watershed is grazed on USFS and ASLD lands. Land uses on private lands are unknown. There are no known diversions from Spring Creek and all surface flow contributes to the discharge of Oak Creek. Camping and recreation are ongoing activities at the FR 796 crossing with Spring Creek.

Williamson Valley Wash and Big Chino Wash

Site Description
Williamson Valley Wash, Yavapai County, Arizona, is a tributary of Big Chino Wash, which is in turn a tributary of the Verde River above Sullivan Lake, near Paulden, Arizona. Big Chino Wash begins near Seligman and flows southeasterly through Chino Valley. Williamson Valley Wash flows north and then east where it joins Big Chino Wash. Both streams are intermittent.

Land Ownership
Land ownership within a 1.6 km (1.0 mi) buffer along Williamson Valley Wash beginning at the Williamson Valley Road bridge and continuing downstream about 9.7 km (6 mi) to T17N R3W, Section 8, NE4 is comprised of private (95%) and ASLD (5%) (Williamson Valley Wash Land Ownership map). This does not include Big Chino Wash. The entire stream reach is abutted by private lands, with State land located away from the stream channel.

Land and Water Uses
Land uses occurring within Williamson Valley and Big Chino washes include agriculture, grazing, and possibly timber and fuelwood cutting. Other uses are unknown.

Collection History
The earliest collection of chub was in 1897 by Gilbert at a location identified as Chino, Arizona (Big Chino Wash) (Table C-11). The specimens are identified as *Gila robusta intermedia* by SMNH, which are now Gila chubs. Gila chub were again collected in 1950 with Sonora sucker from Big Chino Wash. No subsequent collections are available from Big Chino Wash.

Gila chubs were collected from Williamson Valley Wash on the Matli Ranch, downstream of the Williamson Valley Road bridge, in 1990 (Dave Gori, TNC, pers. comm.). A collection of fishes was taken and submitted to the ASU Museum of Fishes, but did not appear in our search. Gila chubs were again collected from an isolated pool in Williamson Valley Wash in 1992 by Bettaso and Anderson in conjunction with the Gila Taxonomy Project (Rob Bettaso, AGFD, pers. comm.). Twenty chubs were collected, frozen, and taken to the University of Texas in Austin. Other reported fishes were mosquitofish and an undetermined sucker species. During flooding in early 1993, that isolated pool was completely filled in with sand and gravel (Tom Liles, AGFD, pers. comm.), however other pools may still exist within the drainage. There are no known populations of Gila chub within Big Chino Wash and Gila chub may be extirpated from that drainage.

Recent Survey Results
Big Chino Wash and Williamson Valley Wash were not surveyed for this project.

San Carlos River flows from an elevation of 1550 m (5100 ft) in the Natanes Mountains to an elevation of 760 m (2500 ft) at San Carlos Reservoir.

Land Ownership
A total of 17,643 hectares (43,596 acres) within a 1.6 km (1.0 mi) buffer zone along 80.4 km (50.0 mi) of the San Carlos River beginning just above San Carlos Reservoir and continuing upstream is owned and managed by the San Carlos Apache Tribe.

Land and Water Uses
The San Carlos River watershed is used by several cattle associations for grazing (Cliff Schlusner, FWS, pers. comm.). The San Carlos Nation is considering allowing prospecting for lithium deposits in the Blue and San Carlos watersheds. Other land and water uses are unknown.

Collection History
The earliest known collection of Gila chubs from the San Carlos River was in 1968 by W. L. Minckley (Table C-13). The only other known collection was by DeMarais in 1983 at an undisclosed location.

Recent Survey Results
Due to access restrictions, the San Carlos River was not surveyed.

Status, Threats, and Management Recommendations
Unknown. Gila chubs are present in the San Carlos River (Stewart Jacks, FWS, pers. comm.), but relative abundances and other fish species are unknown. Lack of historical and current information precludes assigning a status to this population.

Blue River

Site Description
The Blue River is a tributary of the San Carlos River entirely on the San Carlos Apache Indian Reservation, Gila County, Arizona. It flows from an elevation of 1300 m (4280 ft) at Blue River Spring to 850 m (2780 ft) at the San Carlos River confluence.

Land Ownership
A total of 6,705 hectares (16,567 acres) within a 1.6 km (1.0 mi) buffer zone along 20.0 km (12.5 mi) of the Blue River, from its confluence with the San Carlos River upstream to Blue River Spring, is owned and managed by the San Carlos Apache Indian Reservation.

Land and Water Uses
The Blue River watershed is heavily grazed by several cattle associations, and abandoned asbestos mines are present (Cliff Schlusner, FWS, pers. comm.). Other land uses are unknown.

Hole Wildlife Area (BHWA), a human-made impoundment containing nonnative fishes, is located at the headwaters in the San Rafael Valley.

Land and Water Uses
The Santa Cruz River is heavily developed and channelized through Nogales, Sonora, and Nogales and Tucson, Arizona. Sewage effluents enter the Santa Cruz River from treatment plants in Nogales and Tucson. Throughout the watershed, the river is impacted by a wide variety of land uses that include, but may not be limited to: grazing, mining, groundwater pumping, urban developments, sewage treatment discharge, and channelization.

Collection History
The earliest known collection of Gila chubs from the Santa Cruz River was in 1891 by Jouy (Table C-15). They were also collected in 1893 and 1904. Although the ASU Museum Register obtained for this report did not list a collection location for ASU collection #7143, DeMarais (1986) indicated it was from the Santa Cruz River.

The Santa Cruz River, at the gaging station near Lochiel, Arizona was surveyed during Gila topminnow or FFC monitoring from 1988-1995. No Gila chubs were collected, however, the following species were collected: Gila topminnow, longfin dace, Sonora sucker, desert sucker, mosquitofish, green sunfish, largemouth bass, and fathead minnow. Gila topminnows and mosquitofish also were collected from a connected backwater of the Santa Cruz River near Rio Rico, Arizona in 1994.

Recent Survey Results
The Santa Cruz River was not surveyed for this project.

Status, Threats, and Management Recommendations
Extirpated (tentative). The Gila chub is currently extirpated from the Santa Cruz River. It is still present in several tributaries and a tributary spring, Sheehy Spring, near the headwaters in the U.S. Management actions to remove nonnative fish and establishment of conservation easements that would improve habitat conditions in the Santa Cruz River within the San Rafael Valley may allow for the future reintroduction of Gila chubs to that reach.

Cienega Creek

Site Description
Cienega Creek, Pima and Santa Cruz counties, Arizona is a tributary of the Santa Cruz River. It flows north between the Santa Rita and Empire mountains on the west and the Whetstone Mountains on the east, joining Pantano Wash near Vail, Arizona. The headwater elevation of Cienega Creek is about 1520 m (5000 ft), and it flows to an elevation of about 1070 m (3500 ft) at its confluence with Pantano Wash.

Table 9. Relative abundance of fishes collected during Fall Fish Count and Gila topminnow monitoring in Cienega Creek, Santa Cruz County, Arizona in 1985-1995. Data are from AGFD NFDB. Species code abbreviations defined in Appendix A.

Date	Location	Project	Fish collected (% relative abundance)	N collected
850731	Cienega Creek, 31'49'30" 110°34'10"	Topminnow Mon.	POOC AGCH GIIN	unknown
880818	T18S R17E S. 23 NE4 NE4	Topminnow Mon.	POOC (57%), AGCH (39%), GIIN (3%)	n=376
890724	T18S R17E S.12 & 35 T19S R17E S.10	Topminnow Mon.	POOC (54%), AGCH (40%), GIIN (6%)	n=946
891021	T18S R17E S. 23 NE4 SW4	Fall Fish Count	POOC (88%), AGCH (12%), GIIN (<1%)	n=2589
901121	T18S R17E S.23 SE4 SW4 T19S R17E S. 10 NE4 T19.5S R17E S. 15 SE4 SE4	Fall Fish Count	POOC (71%), AGCH (29%), GIIN (<1%)	n=717
901130	T16S R17E S. 30 NE4 NE4 T16S R16E S.14 SE4 SE4 T16S RI7E S. 19 SW4 SE4	Fall Fish Count	AGCH (100%)	n=936
920618	T19S R17E S. 10 NE4	Topminnow Mon.	POOC (100%)	n = 69
921027	T18S R17E S. 12 NE4	Fall Fish Count	GIIN (55%), AGCH (36%), POOC (9%)	n=94
921028	T19S R17E S. 15 SE4 SE4	Fall Fish Count	POOC (99%), GIIN (<1%)	n=3224
921031	T195 R17E S. 10 NE4 SE4 T19S R17E S. 3 NE4 SE4	Fall Fish Count	POOC (97%), AGCH (3%), GIIN (<1%)	n=7501
921110	T185 R17E S. 13 NE4 NW4	Fall Fish Count	AGCH (72%), POOC (27%), GIIN (1%)	n=71
931012	T19S R17E S. 15 SE4 SE4	Fall Fish Count	POOC (98%), GIIN (2%)	n=794
931013	T19S R17E S. 10 NE4 SE4 T19S R17E S. 3 NE4 SE4	Fall Fish Count	AGCH (61%), POOC (39%)	n=896
931014	T18S R17E S.23 SW4 NM T18S R17E S. 23 NM SE4	Fall Fish Count	AGCH (89%), POOC (11%). GUN (<1%)	n=1724
931015	T18S R17E S. 13 NM NW4 T18S R17E S. 12 NM SE4	Fall Fish Count	AGCH (99%), GIIN (1%)	n=370
931028	T19S R17E S. 15 NM NM	Fall Fish Count	POOC (78%), GIIN (14%), AGCH (8%)	n=450
940721	T19S R17E S. 15 NM SE4 T18S R18E S. 6 SE4 SW4	Topminnow Mon.	AGCH (79%), POOC (21%)	n=400
950724	T18S R17E S. 14 SE4 SE4 T18S R17E S. 12 NM SE4	Topminnow Mon.	AGCH (58%), POOC (29%), GIIN (13%)	n=857

Land Ownership

Land ownership along Sabino Canyon within a 1.6 km (1.0 mi) buffer beginning at the confluence with Tanque Verde Wash and continuing upstream 29.5 km (18.3 mi) to the USGS gauging station at 2190 m (7200 ft) elevation is comprised of Coronado National Forest (67%) and private (33%) lands. Private lands on the Sabino Canyon Land Ownership Map are within the city limits of Tucson, Arizona, but private land is also present at the headwaters in Summerhaven, outside of the buffer zone.

Land and Water Uses

Headwaters of Sabino Canyon are developed within the residential community of Summerhaven. Downstream of Summerhaven, Sabino Canyon flows about 16 km (10 mi) through the Coronado National Forest, Pusch Ridge Wilderness Area, where wilderness recreation is the only impact. Sabino Canyon then enters the USFS Sabino Canyon Recreation Area where recreation is again the dominant land use. A paved access road is maintained by the USFS with nine bridged crossings, each of which forms a formidable waterfall and barrier. Downstream from the recreation area, Sabino Canyon enters the Tucson city limits where land uses are mostly residential and industrial.

Collection History

The earliest known collection of Gila chubs was in 1929 by Kranzther. Many collections were made in Sabino Canyon in subsequent years (Table C-17). FFC surveys were conducted by AGFD personnel and volunteers in 1989, 1990, and 1992 through 1994 (Table 10).

Dudley (1995) provided information on the progressive upstream movement of green sunfish over the past 12 years. Green sunfish were found above bridge one in 1982, above bridge four in 1983, above bridge six in 1984, above bridge seven in 1988, and above bridge eight in 1994. FFC surveys also reported green sunfish above bridge eight in 1993. People are suspected of moving green sunfish above the barriers.

Investigations into interactions between the Gila chub and green sunfish were conducted by Dudley (1995). He reported static distributions of Gila chub and green sunfish during the period of study (fall 1993 to fall 1994). Gila chubs were found in lower densities in lower Sabino Canyon where green sunfish were more abundant. Habitats without green sunfish held more Gila chubs. Also, no Gila chubs under 40 mm (1.6 in) total length were observed anywhere in Sabino Canyon where they were sympatric with green sunfish, although they were observed in habitats not occupied by green sunfish. Dudley reported that green sunfish as small as 51 mm (2 in) total length readily preyed on young Gila chubs 20 to 25 mm (0.8 to 1.0 in) total length, and that the presence of Gila chubs in lower Sabino Canyon is the result of dispersal from upstream, not the result of reproduction and recruitment in lower Sabino Canyon.

Attempts should be made by AGFD and Coronado National Forest to remove green sunfish from as much of lower Sabino Canyon as possible.

Sonoita Creek

Site Description
Sonoita Creek, Santa Cruz County, Arizona is a tributary of the Santa Cruz River. Much of Sonoita Creek is dry throughout most of the year. Less than 16 km (10 mi) of perennial flow remain. The creek flows from an elevation of 1,460 m (4800 ft) at its origin, to an elevation of 1050 m (3440 ft) at the Santa Cruz River confluence. Monkey Spring is in a tributary of Sonoita Creek at an elevation of 1390 m (4550 ft). Monkey Spring has rich aquatic vegetation, which includes: *Lilaeopsis recurva, Ludwigia natans* (recorded in Arizona only from Monkey and Cottonwood Springs), unidentified mosses, *Potamogeton foliosus,* the sometimes emergent *Hydrocotyle verticilliata,* and *Chara* spp. (Minckley 1969). Minckley (1969) reported Monkey Spring water temperatures at the source spring to average about 82° F. The pH at the source ranged from about 6.8 to 7.0. Monkey Spring has no detectable turbidity and dissolved oxygen concentrations were low (2.3 to 2.6 mg/l). Hendrickson and Minckley (1984) provide a more complete description of historical and present habitat conditions.

Land Ownership
A Land Ownership Map was not produced for this stream because Gila chub is considered extirpated (Minckley 1973). Sonoita Creek ownership is shared by The Nature Conservancy (TNC), ASLD, Arizona State Parks Department, and private holdings. Many of the Sonoita Creek tributaries originate in the Coronado National Forest, but Sonoita Creek does not flow through it. Monkey Spring is privately owned and access is controlled by the landowner.

Land and Water Uses
Habitat changes occurred in Sonoita Creek as early as the 1890s. Adverse effects from arroyo cutting included bank erosion, moving sand bottoms, and invasion of floodplains by extensive woody vegetation. Beginning at the headwaters near Sonoita, the creek is dry until just upstream of Cottonwood Spring. Cottonwood Spring and another spring a short distance upstream provide some surface water to the creek, which flows for about 400 m, but most of the flow is diverted to downstream water users via an underground pipe. The stream then becomes ephemeral again due to course alluvium which allows percolation of surface flow. The stream remains dry until near Patagonia, where bedrock forces water to the surface and a wastewater treatment facility augments naturally appearing surface flow. The stream remains perennial for several kilometers, through the TNC Sonoita Creek Preserve to Patagonia Lake and further downstream, where groundwater maintains surface flow. Within 4.8 km (3 mi) of the confluence with the Santa Cruz River, it again sinks into the stream bottom.

Status, Threats, and Management Recommendations
Extirpated. Based on available information, Gila chubs are considered extirpated from Monkey Spring and Sonoita Creek. It is unlikely that suitable habitat will again be available in Monkey Spring for reintroduction of Gila chubs.

Sheehy Spring

Site Description
Sheehy Spring, Santa Cruz County, Arizona lies adjacent to the Santa Cruz River in the San Rafael Valley near Lochiel. Available habitat is limited to one large pool and several smaller ones in a spring-fed cienega. Bagley et al. (1991) reported that the largest pool was 15 m long x **4** m wide x 2.2 meters deep (49 ft long x 13 ft wide x 7.2 ft deep). Thick blackberry bushes and ornamental trees effectively protect the large pool from direct impacts by grazing cattle. Elevation at the spring is 1425 m (4675 ft).

Land Ownership
Land ownership within a radius of 1.6 km (1 mi) around the spring is entirely private and managed by the San Rafael Cattle Company.

Land and Water Uses
The spring is modified, dammed, and transported through culverts and ditches for agricultural purposes by the landowner. The cienega and surrounding grasslands are grazed by cattle on a rotational basis. Grazing duration, season, and stocking rates are unknown.

Collection History
Gila chubs were first collected from Sheehy Spring in 1939 (Table C-19). Early collections in UMMZ refer to specimens as *G. robusta* or *G. r. intermedia,* however they subsequently have been identified as *G. intermedia* (Minckley 1973; Rinne 1976; DeMarais 1986, 1992). The spring also provided habitat for the endangered Gila topminnow. Sheehy Spring has been monitored periodically since its discovery, usually to determine the status of topminnow. Mosquitofish were first reported from Sheehy Spring above the small dam in 1979 (Meffe et al. 1983). Prior to this they were commonly found below the dam and in the Santa Cruz River (Minckley et al. 1977). Topminnow declined following the introduction of mosquitofish, until they disappeared in 1988 (Bagley et al. 1991).

Minckley et al. (1977) reported capturing 85 Gila chub above the dam and 22 below using electrofishing gear. FFC volunteers monitoring Sheehy Spring reported capturing nine Gila chub in 1989 and one in 1991, using seines and dipnets.

Recent monitoring by the AGFD (1985 to present), using seines and dipnets, has focused on searching for remaining topminnow, with Gila chub collection being incidental. Methods used during topminnow monitoring vary widely, and collections of Gila chubs are not directly

cedar. For a more complete description of historic and present habitats see Hendrickson and Minckley (1984) and Jackson et al. (1987).

Land Ownership

Land ownership within a 1.6 km (1.0 mi) buffer zone along the San Pedro River from the Arizona-Mexico boundary north to Redington, Arizona is comprised of private (41%), BLM (34%), State (24%), and United States Army, Fort Huachuca (> 1%) lands (San Pedro River Land Ownership Map). Lands in Sonora, Mexico (about 1803 km^2 [696 mil of the San Pedro River watershed) are privately owned ranches and mines with limited access. BLM lands along the San Pedro River from the international border upstream to near St. David were designated as a Riparian National Conservation Area (RNCA) by Congress in 1988. There are several Research Natural Areas within the RNCA. North of St. David downstream to Redington, lands along the river channel are primarily private. Uplands away from the river belong to the ASLD.

Land and Water Uses

Land and water uses within the San Pedro River watershed include agriculture, mining, grazing, logging, industrial, municipal, residential, recreation, and wildlife. Appropriated water rights, as governed by state law, are beyond the scope of this report. Some of the known factors that directly affect water quality and fish are the Cananea mine in Mexico, San Manuel copper mine, groundwater withdrawals for agriculture, municipal uses, and sewage effluent from communities in Mexico and Arizona.

Collection History

The San Pedro River historically supported at least 13 native fish species (Jackson et al. 1987). Gila chubs were first collected from the San Pedro River by J.H. Clark in 1851. Later collections occurred at Fairbank, Arizona, 2.5 km (1.5 mi) above Fairbank (Chamberlain 1904), and at St. David, Arizona in 1912 by the U.S. Bureau of Fisheries (Table C-20). SMNH museum collections identify *Gila* specimens from the upper San Pedro River as *G. r. intermedia*. Rinne (1969, 1976) identified chubs from the upper San Pedro River drainage as *G. intermedia* based on specimens from Bass, Redfield, Turkey, and O'Donnell canyons and the Babocomari River. Based on these collections and additional information (Minckley 1973; DeMarais 1986, 1992), Gila chubs historically occupied the upper San Pedro River. Downstream portions of the San Pedro River near the Gila River, including Aravaipa Creek, contained *G. robusta* that were phenotypically intermediate between the two species (based on the distribution of the species in tributaries to the San Pedro River as described by DeMarais 1986).

Surveys conducted in 1990 at eight locations from Hereford downstream to St. David reported only two native species, longfin dace and desert sucker (Stefferud and Stefferud 1990). Nonnative fish collected included mosquitofish, black bullhead, and fathead minnow.

chub existence. Extreme pollution from the Cananea mine occurred in 1979, and although leaching ponds have since been secured, there is the threat of more pollution problems from the extensive, open pit copper mines (Jackson et al. 1987).

Redfield Canyon

Site Description
Redfield Canyon, Graham and Pima counties, Arizona, is a west flowing tributary to the San Pedro River. Redfield Canyon originates in the southern portion of the Galiuro Mountains near an elevation of 1520 m (5000 ft) and meets the San Pedro River near Redington, Arizona at an elevation of 880 m (2900 ft). Perennial flow in Redfield Canyon begins at the confluence with Sycamore Creek and continues downstream at least 5.6 km (3.5 mi). An unknown distance below that point is perennial, becoming subsurface somewhere before its confluence with the San Pedro River. A 5 m (16 ft) high boulder waterfall was present in Redfield Canyon in 1983 and 1991 at a point 0.7 km (0.43 mi) below the mouth of Sycamore Canyon. The waterfall effectively prevented fishes from dispersing above that point (Johnson 1983, Griffith and Tiersch 1989, and Gori 1993). In 1991, there were a few scattered pools in Redfield Canyon for a distance of 8 km (5 mi) above the confluence with Sycamore Canyon (Gori 1991).

Land Ownership
Land ownership within a 1.6 km (1.0 mi) buffer along Redfield Canyon beginning at the confluence with the San Pedro River and continuing 30.9 km (19.2 mi) upstream is comprised of State (55%), private (20%), USFS (16%), and BLM (8%) lands. All State land within the Muleshoe Ranch Cooperative Management Area has been traded to the BLM (Dave Gori, TNC, pers. comm.). Private lands and an unknown percentage of federal lands (USFS and BLM) are included in the management of TNC's Muleshoe Ranch CMA.

Land and Water Uses
Low level livestock grazing occurs in the lower Redfield Canyon drainage. A limited amount of OHV use may be present along the lower canyon, accessed from Cascabel Road; however, this is downstream from the perennial reach. Impact from two small mining claims in the upper drainage is unknown, but should be minimal. TNC lands are managed for the conservation and preservation of natural resources. No other land or water uses are known in Redfield Canyon. Upstream perennial reach of Redfield Canyon from Gori (1993) is shown on the Land Ownership Map, but not downstream end of perennial flow.

Collection History
The first documented collection of Gila chubs in Redfield Canyon was in 1961 (Table C-21). A number of collections of Gila chub occurred from 1976 through 1983. Associated species collected included longfin dace, Sonora sucker, and speckled dace.

Bass, Hot Springs, and Double R Canyons

Site Description
Bass Canyon is a perennial stream in Graham and Cochise counties, Arizona. It is a tributary of Hot Springs Canyon, which flows into the San Pedro River at Cascabel. Double R Canyon is a tributary of Bass Canyon. These streams flow south and westerly and drain the southern edge of the Galiuro Mountains and the western edge of the Winchester Mountains. Elevations within the drainage range from 1905 m (6250 ft) at Bass Canyon headwaters and 1370 m (4500 ft) in Double R Canyon down to 1200 m (3950 ft) at the confluence of Bass and Hot Springs canyons and 960 m (3150 ft) at the confluence of Hot Springs Canyon and the San Pedro River.

Perennial water was identified by Gori (1993) for these streams as follows: Hot Springs Canyon was perennial in 1991 from just above the Bass Canyon confluence downstream for a total of 4.5 km (2.8 mi), Bass Canyon was perennial from the Hot Springs Canyon confluence upstream 4.8 km (3 mi) above which was dry for 8 km (5 mi), and Double R Canyon was perennial for 1.9 km (1.2 mi) above the Bass Canyon confluence, above which was ephemeral.

Table 11. Survey results in Redfield Canyon, Graham and Pima counties, Arizona, for Fall Fish Count and The Nature Conservancy annual monitoring. Species code abbreviations defined in Appendix A.

FFC T11S R19E Sec. 35	1988 (n=228)	1989 (n=102)	1990 (n=637)	
	AGCH (74%) CAIN (12%) PACL (8%) RHOS (4%) GIIN (2%) LECY (<1%) PIPR (<1%) PAxCA (<1%)	AGCH (77%) LECY (8%) CAIN (5%) PACL (4%) RHOS (4%) GIN (2%)	AGCH (67%) LECY (15%) PACL (14%) CAIN (2%) RHOS (1%) GIN (<1%) PAxCA (<1%)	
TNC T11S R2OE Sec. 28 & 32	1991 (n=568)	1992 (n=308)	1993 (n=523)	1994 (n=523)
	GIN (72%) CAIN (14%) AGCH (7%) RHOS (7%) LECY (<1%)	GIN (42%) CAIN (22%) RHOS (22%) AGCH (10%) LECY (3%) PACL (<1%)	AGCH (30%) GUN (30%) RHOS (28%) CAIN (12%)	GIIN (33%) RHOS (28%) AGCH (22%) CAIN (17%)

Land Ownership
Land ownership was calculated for Bass Canyon from its confluence with Hot Springs Canyon upstream 6.1 km (3.8 mi) (Bass Canyon Land Ownership Map). This area includes most of Double R Canyon and approximately 3.2 km (2 mi) of Hot Springs Canyon near the confluence with Bass Canyon. Ownership is comprised of BLM (62%), private (31%), and State Trust (7%) lands. All State land within the Muleshoe Ranch CMA was traded to the BLM. An unknown

inappropriate for Gila chub. In Hot Springs Canyon, Gila chub are present from 0.4 km (0.25 mi) below the Bass Canyon confluence downstream to the end of perennial flow, 0.4 km (0.25 mi) below the TNC Muleshoe Ranch Preserve boundary. The occurrence of Gila chub within this reach of Hot Springs Canyon is sporadic due to the limited number of pools, however chubs are commonly found where good pool habitat does exist.

Recent Survey Results

Based on the amount and quality of information available from the TNC Annual Monitoring. Bass Canyon, Hot Springs Canyon, and Double R Canyon were not surveyed for this project.

Status, Threats, and Management Recommendations

Stable-Threatened. Gila chubs are uncommon, but usually present, in the fish community in Bass Canyon. They appear to be present less consistently in Hot Springs and Double R canyons. Relative abundance of Gila chubs appears to fluctuate yearly, likely based on environmental conditions. Due to a lack of long-term data, it is not possible to determine if there have been declines in the distribution or abundance of Gila chubs in Bass, Hot Springs, or Double R canyons. Habitat availability appears limited by seasonal fluctuations of surface water.

Table 12. Relative abundance of fishes collected from Bass, Hot Springs, and Double R canyons, Graham and Cochise counties, Arizona. during TNC monitoring 1991-1994. Species code abbreviations defined in Appendix A.

Stream/Year	1991	1992	1993	1994
Hot Springs Canyon	AGCH (63%) PACL (19%) RHOS (17%) CAIN (<1%) GIIN (<1%) (n=1521)	AGCH (58%) RHOS (35%) PACL (7%) CAIN (<1%) (n=1671)	AGCH (51%) PACL (25%) RHOS (21%) CAIN (2%) GIIN (<1%) (n=4262)	AGCH (59%) RHOS (21%) PACL (17%) CAIN (1%) GIIN (<1%) (n=2118)
Bass Canyon	AGCH (55%) GIIN (20%) PACL (16%) CAIN (5%) RHOS (4%) (n=490)	AGCH (60%) RHOS (23%) PACL (14%) GIIN (2%) CAIN (<1%) (n=1550)	AGCH (46%) RHOS (36%) PACL (13%) GIIN (5%) CAIN (<1%) (n=1400)	AGCH (57%) RHOS (24%) PACL (12%) GIIN (4%) CAIN (2%) (n=2004)
Double R Canyon	AGCH (70%) RHOS (30%) (n=508)	AGCH (53%) RHOS (47%) (n=176)	RHOS (85%) AGCH (15%) GIIN (<1%) (n=241)	AGCH (88%) RHOS (8%) PACL (3%) GIIN (<1%) (n=383)

The presence of largemouth bass, collected in 1989, is a cause of some concern. Johnson (1983) identified an artificial pond present in upper Bass Canyon on Larsen Ranch that apparently

Collection History

Gila chubs were first collected from the Babocomari River in 1892 near Fort Huachuca (Table C-23). The next documented collection was in 1950, 5.6 km (3.5 mi) below the Babocomari Ranch. Nonnative fishes first appeared in museum collections in the late 1960s. The following nonnatives have been collected in the Babocomari River: largemouth bass, bluegill, goldfish, and yellow bullhead. Other native species documented in the Babocomari River are desert sucker, Sonora sucker, and longfin dace.

Data collected by AGFD FFC volunteers in 1988 indicated Gila chub and longfin dace presence only in T-4 Spring. Relative abundances calculated from their data (n=142) were 51 percent Gila chub and 49 percent longfin dace. They also sampled 1.6 km (1.0 mi) downstream of the dam and 200 m (660 ft) upstream of the dam, in an isolated backwater, but found only largemouth bass and yellow bullhead.

Recent Survey Results

In 1995, the only native fish collected in the Babocomari River below the Babocomari Ranch impoundment was Sonora sucker (5%). Nonnatives included largemouth bass (46%), mosquitofish (41%), green sunfish (6%), and bluegill (1%) (total n=111). Mosquitofish were more abundant than our sampling indicated, due to bias of electroshocking gear and dipnetters who avoided netting schools of mosquitofish to focus on areas with higher potential of producing Gila chubs.

Sampling conducted downstream from the ranch near Huachuca City and at the confluence with the San Pedro River resulted in the capture of longfin dace (34%), fathead minnow (23%), mosquitofish (20%), green sunfish (14%), Sonora sucker (4%), and desert sucker (3%) (total n=159).

Middle portions of the Babocomari River below the Babocomari Ranch impoundment were greatly incised and the flood plain was very narrow. The riparian gallery was generally well developed and, where terraces were present, dominated by mature cottonwoods and willows. Wider, less incised ephemeral channel reaches were dominated by shrubs and grasses and lacked a riparian overstory. Root wads and woody debris were abundant within the riparian gallery and provided some cover for fish. Banks were generally vertical and undercut to varying degrees, and stabilized by roots of grass and other vegetation. The dominant habitat type available was pool, with few riffles and some short runs. Substrates were dominated by silt in the pools and by gravels and pebbles in the short reaches of riffle separating each pool. Long, slow-moving runs were also abundant and consisted of mostly sand and gravel substrates. Overall, this stream appeared to provide suitable habitat for Gila chub, although none were collected.

Status, Threats, and Management Recommendations

Unknown. Historical information on distribution and abundance of the Gila chub is insufficient to determine declines in abundance. The Gila chub is believed extirpated from the Babocomari

Land and Water Uses

Perennial water begins at springs on the Canelo Hills Cienega Preserve and continues downstream into the southern portions of the NAS Research Ranch, about 3.2 km (2 mi) (perennial reach provided by Gori [1993] is shown on the Land ownership Map). Those portions of O'Donnell Canyon on the Canelo Hills Cienega Preserve and the NAS Research Ranch are managed to preserve natural habitats and wildlife. Livestock grazing on these properties does not occur; however, the upper portions of the watershed on private and USFS property are grazed. Several dams exist, including a series of earthen check dams in the vicinity of the dorm house on the Research Ranch and two cinder block dams on the southern portion of the ranch. A cement barrier was constructed on the Canelo Hills Cienega Preserve to prevent head-cutting and protect the cienega.

Collection History

The first documented collection of Gila chubs from O'Donnell Canyon was in 1977 by O'Brien and Ginnelly (Table C-24). Other species reportedly collected at the same location and date were longfin dace and Sonora sucker. Subsequent collections by Johnson (1978) and DeMarais in 1983 did not report associated species.

AGFD conducted surveys in O'Donnell Canyon in 1989, 1991, 1992, and 1993 to monitor reintroduction of Gila topminnow (Table 13). Gila chub was the only species recorded from a site on the Audubon Research Ranch in 1989. No fish were caught from a location called O'Donnell Tank in 1989 or 1991. In 1992, Gila chub (45%) and green sunfish (55%) were caught at a site on the Audubon Research Ranch. In 1993, longfin dace (65%), Gila chub (26%), and green sunfish (10%) were collected from the same location.

Table 13. Fish collections from O'Donnell Canyon, Santa Cruz County, Arizona during annual Gila topminnow monitoring. Species code abbreviations defined in Appendix A.

Location	Date	relative abundance of fish collected (%), total n collected
T21S R18E S. 28 SW4 SE4	890726	GIIN (100%), n=5
O'Donnell Tank T21S R18E S. 28 SW4 SE4	890726, 910106	None
T21S R18E S. 28 SW4 SE4	920617	LECY (55%), GIIN (45%), n=55
T21S R18E S. 28 SW4	930811	AGCH (65%), GIIN (26%), LECY (9%), n=155

In 1991, biologists with TNC established four fixed monitoring stations in O'Donnell Canyon. They were monitored in 1991, 1992, and 1994. Gila chubs were collected all three years (Table 14). Dave Gori (TNC, pers. comm.) indicates that green sunfish are currently present in O'Donnell Canyon upstream of the headcut control dam.

climatological factors that affect availability of surface water. Vegetation above the headcut control structure is very dense, and it is unknown whether Gila chub are present.

Collection records indicate that Post Canyon once supported Gila chub. Recent surveys indicate that they are no longer found there and should be considered extirpated. However, this location (especially the Post Canyon impoundment) should be considered for an augmentation stocking of Gila chub from O'Donnell Canyon.

Based on studies conducted by Dudley (1995), green sunfish could be suppressing this Gila chub population's abundance and recruitment. Attempts should be made to remove green sunfish from O'Donnell Canyon above and below the headcut control structure. Investigations into the suitability of habitat above the headcut control structure should be conducted and Gila chub moved into that habitat, if it appears suitable.

Turkey Creek

Site Description
Turkey Creek, Santa Cruz County, Arizona, is a tributary of O'Donnell Canyon. Turkey Creek flows north from the northeastern portion of the Canelo Hills and western Huachuca Mountains near an elevation of 1585 m (5200 ft) to the confluence with O'Donnell Canyon at an elevation of 1430 m (4700 ft). According to Gori (1993), at least 3.2 km (2 mi) of Turkey Creek were perennial from the Highway 83 crossing downstream. However, the lower 1.6 km (1 mi) of this reach consisted of widely separated small pools that were nearly dry in 1995. Habitat conditions on private lands upstream of the highway are unknown.

Land Ownership
Land ownership within a 1.6 km (1.0 mi) buffer along Turkey Creek beginning at the confluence with O'Donnell Canyon and continuing upstream 15.7 km (9.8 mi) to State Highway 83 is comprised of USFS Coronado National Forest (52%), private (34%), and BLM (13%) lands. A majority of the stream length within the delineated area, including holdings by the USFS and BLM, is managed under a cooperative agreement with the NAS Research Ranch. Upstream of the NAS Research Ranch, lands are mostly privately owned.

Land and Water Uses
Locations of known perennial water from Gori (1993) are identified on the Turkey Creek Land Ownership Map. Cattle grazing does not occur on lands managed by the Audubon Research Ranch, including BLM and USFS lands within the Research Ranch boundaries. Cattle grazing does occur on BLM and USFS land elsewhere in the watershed. Other land uses on private lands are unknown, but private property upstream of the USFS Administration site appeared to be heavily grazed and pastures were noted within the flood plain.

Land and Water Uses

Land and water uses on the Reservation and private land are unknown. BLM lands are subject **to** multiple uses as mandated by Congress and include: grazing, logging, mining, and recreation uses, including OHV. Land along Bonita Creek within the BLM's Gila Box RNCA is not currently subject to any of the listed activities, however several mining claims are being reviewed (Mike McQueen, BLM, pers. comm.). The upper portion of Bonita Creek from the Reservation Boundary downstream to the "Narrows" is grazed only in winter. No riparian grazing should be occurring below this point (Mike McQueen, BLM, pers. comm.). BLM does maintain some low volume pumps to provide water for livestock outside the riparian area. The city of Safford takes water from Bonita Creek to supply municipal uses. They also have a maintenance right-of-way from the Gila River upstream to the intake structure.

In 1995, Safford, Arizona was considering options to increase their water rights and withdrawals from Bonita Creek (Jeff Simms, BLM, pers. comm.). BLM has a "reserved water right" from Congress for remaining surface flow, which may be in jeopardy if Safford secures increased water rights.

Collection History

The earliest reported collection of *Gila* in Bonita Creek was in 1950 by Miller and Winn near the confluence with the Gila River (Table C-26). These specimens are reported as *G. robusta* by the UMMZ. However, the specimens were never re-examined, and other collections from Bonita Creek have been identified as *G. intermedia* (DeMarais 1986). Gila chubs have been collected many times since 1950, and recent surveys by BLM fisheries biologists in 1992 and 1993 provide good data on distribution and abundance.

Jeff Simms (BLM) conducted an inventory of lower Bonita Creek (lowest 6.0 km [3.75 mip in June and July 1992. Results of these surveys were made available in a BLM Memorandum to the Gila Resource Area Manager. The following fishes (n=25,865) were collected in 21,000 seconds of electroshocking: longfin dace (77.6%), Sonora sucker (12.1%), desert sucker (5.4%), speckled dace (3.1%), yellow bullhead (0.7%), fathead minnow (0.4%), Gila chub (0.2%), carp (0.1%), channel catfish (0.1%), and mosquitofish (0.01%). Gila chubs collected were usually solitary and heavily parasitized by *Lernaea.* Minckley and Sommerfeld (1979) found that lower portions of Bonita Creek suffered an oxygen deficit in summer, with concentrations below the 6.0 mg/l (less than 60% saturation) recommended for fish. They also reported that channel catfish occasionally invade the lower few kilometers of Bonita Creek. Simms noted that young chubs were uncommon in this reach of Bonita Creek in 1992, even following their peak breeding season. He reported that mosquitofish were highly under-represented in the sampling due to electroshocking bias.

A fish salvage operation was conducted in March 1993 within a 1.4 km (0.85 mi) section of the lower 6.0 km (3.75 mi) of Bonita Creek. It produced 17,500 fish, of which only 67. were Gila chubs. Many of the chubs had visible signs of skin infections.

Gila River near 1000 m (3300 ft) elevation. Twenty one species of fish have been collected from Eagle Creek, which included 10 native and 11 nonnative fishes (Marsh et al. 1990).

Marsh et al. (1990) described the stream as follows: headwater reaches of Eagle Creek have a gradient of 90 m/km, which moderates to 4 m/km when the stream flows about 20 km (12 mi) through a broad, grassy valley. The stream then flows about 64 km (40 mi) through deep steep-walled canyons with a gradient of 7.4 m/km to the Gila River. Flows in Eagle Creek are augmented by an interbasin transfer of water from the Black River pumped directly into Willow Creek, a tributary of Eagle Creek. Minckley and Sommerfeld (1979) computed that the average annual discharge of Eagle Creek for the period 1946 to 1969 had been augmented 27 percent by interbasin transfer of water from the Black River into Willow Creek.

Land Ownership

Eagle Creek is 105.5 km (65.6 mi) long from its confluence with the Gila River upstream to East Eagle Creek, above Honeymoon Campground. Land ownership within a 1.6 km (1.0 mi) buffer around this reach of stream is comprised of San Carlos Apache Indian Reservation (33%), Apache-Sitgreaves National Forest (31%), private lands (16%), BLM (14%), and State Trust Lands (7%).

Land and Water Uses

The watershed is currently affected by cattle grazing, logging, and extensive open pit mining. Over the years, several diversion structures have been constructed, washed out by floods and rebuilt. Currently, a diversion dam about 5 m (16 ft) in height is present in lower Eagle Creek and water is pumped via an aqueduct by Phelps Dodge to mining operations near Morenci. Water is diverted or pumped out of the creek for mining, ore processing, municipal, and industrial uses.

Collection History

Ten native fishes are known from Eagle Creek that include the following species; an undetermined native trout, loach minnow, spikedace, longfin dace, speckled dace, Sonora sucker, desert sucker, razorback sucker (reintroduced), roundtail chub, and Gila chub. Loach minnow was not collected from 1950 until 1995 (Paul Marsh, ASU Center for Environmental Studies, pers. comm.). Eleven nonnative fishes have been collected from Eagle Creek including; rainbow trout, carp, red shiner, fathead minnow, yellow bullhead, channel catfish, flathead catfish, mosquitofish, smallmouth bass, largemouth bass, and black bullhead (Marsh et al. 1990).

Identification of *Gila* from Eagle Creek remains problematic. DeMarais (1995) recommended that specimens should be designated as *G. intennedia* or *G. robusta* only after careful evaluation of diagnostic characters. Therefore, unless specimens have been positively identified based on diagnostic characteristics provided by Rinne (1969), identification will remain suspect.

Recent Survey Results
Eagle Creek was not surveyed for this project due to existing surveys.

Status, Threats, and Management Recommendations
Unstable-Threatened. The identification and presence of *G. intermedia* in Eagle Creek remains problematic. Data from Marsh et al. (1990) indicate that fish most closely resembling *G. intermedia* were present at only one location, Honeymoon Campground. The rest of the stream was inhabited by *G. robusta.* DeMarais (1986) indicated that specimens from upper Eagle Creek (ASU Museum Catalog No. 7836 and uncatalogued specimens) were identified as *G. intennedia,* although their morphologies may reflect minor introgression of *G. robusta* characters. According to DeMarais (1992) ongoing hybridization with roundtail chub may be occurring in Eagle Creek, the only stream the two species are found together.

San Simon River

Site Description
The San Simon River is a Gila River tributary that originates in Hidalgo County, New Mexico, and flows through Cochise and Graham counties, Arizona. The river runs from an elevation of 1280 m **(4200 ft)** at the headwaters in New Mexico to an elevation of 905 m (2970 ft) at the Gila River confluence near Solomon, Arizona. The San Simon River passes about 145 km (90 mi) through the San Simon Valley (including Arizona and New Mexico) to the Gila River confluence. Historically the watershed was a broad grassland with scattered mesquites. A stream flowed through braided channels between marshy banks. It changed rapidly after about 1885 due in part to heavy grazing by large herds of cattle (Hendrickson and Minckley 1984).

Land Ownership
A Land Ownership Map was not produced for the San Simon River, but ownership is known to include mainly BLM, with some State and private holdings.

Land and Water Uses
Historically, the San Simon Valley was heavily grazed. San Simon Cienega was a well known watering location for pioneers, military, and survey parties working in the region. Arroyo cutting early in this century destroyed much of the cienega along the San Simon River, including habitats near San Simon Cienega. The Bureau of Land Management constructed a cement dam to preserve remaining cienega habitat, but water tables dropped to the point that water must now be pumped into this marsh, the last remaining cienega in the San Simon Valley, to artificially maintain it (Hendrickson and Minckley 1984).

Collection History
Gila chubs historically inhabited cienegas of the upper San Simon River (Minckley 1969; Rinne 1969). The UMMZ has specimens collected in 1939 from San Simon Cienega, 1.6 km (1 mi) north of Warner Ranch (Table C-28). They were identified as *G. robusta* x *G. intermedia*

Land and Water Uses

Land managed by USFS is subject to multiple uses as mandated by Congress, and is currently grazed, although middle portions of Harden Cienega and Dix Creeks are within narrow canyons that are not accessible to cattle (Bob Csargo, USFS, pers. comm.). Other specific uses are not currently known.

Collection History

The only known museum record of Gila chub from Harden Cienega Creek was collected in 1988 by DeMarais (Table C-29). Anderson and Turner (1977) reported collecting 10 *Gila* specimens, which they reported as "grahami." They preserved all 10 specimens, however, these specimens are not in museums contacted for this status review. Montgomery (1985) surveyed Harden Cienega Creek and Dix Creek and reported *G. robusta* from Harden Cienega Creek, although they are now considered Gila chub based on identification of subsequent specimens collected by DeMarais (ASU 12171) . Personnel from ASU surveyed Harden Cienega Creek and Dix Creek again in 1995 (Table 15) and reported *G. intermedia* from both streams, the first time *Gila* have been reported from Dix Creek.

Recent Survey Results

Harden Cienega Creek was not surveyed for this project.

Status, Threats, and Management Recommendations

Unknown. No collections to date have reported nonnatives in Harden Cienega or Dix Creek. Lack of historical distribution and abundance data do not allow for determining the qualitative or quantitative status of these populations. All past collections were made in the lower portions of both streams, and upstream distributional ranges are unknown, although suitable habitat may not be available. Additional surveys are strongly recommended for both streams.

SUMMARY AND CONCLUSIONS

PRESENT DISTRIBUTION

Gila chubs are currently limited to 24 isolated Gila River basin streams or cienegas in central and southern Arizona (Table 16, Fig. 2) and northern Sonora, Mexico. Bancroft et al. (1980) listed *G. intermedia* from Webber Creek. Original data sheets record *G. r. robusta* as the species caught (Rob Clarkson, Bureau of Reclamation, pers. comm.), and Silvey et al. (1984) reported *G. r. robusta* as being present. Webber Creek is a tributary of the East Verde River, which contains the phenotypically intermediate roundtail chub (DeMarais 1986).

The species is considered extirpated in New Mexico, including the San Francisco, Gila. and San Simon River drainages (Bestgen and Propst 1989; Sublette et al. 1990). The current known distribution of Gila chubs in Mexico is limited to Cienega los Fresnos and Cienega la Cienegita, adjacent to the Arroyo los Fresnos (tributary of the San Pedro River), within 2 km (1.2 mi) of the Arizona-Mexico boundary. Cienega los Fresnos lies in a natural grassland used for livestock grazing without adequate management. Other populations may persist in the upper San Pedro River and Santa Cruz River drainages, but comprehensive surveys have yet to be conducted.

Gila chubs formerly occupied, but are (or may be) now extirpated from the following aquatic systems:

- Cave Creek/Seven Springs
- Sonoita Creek (Monkey Spring)
- Santa Cruz River
- Turkey Creek
- Queen and Arnett Creeks
- Garden Canyon (re-introduced)
- Fish Creek
- San Simon River (Arizona and New Mexico)
- San Pedro River (Arizona only)
- Big Chino Wash
- Post Canyon (tributary to O'Donnell Canyon)

Gila chubs currently inhabit the following aquatic systems:

- T-4 Spring (Babocomari River)
- Blue River
- Cienega Creek
- Eagle Creek
- Indian Creek
- Larry Canyon (stock from Silver Creek)
- O'Donnell Canyon
- Red Tank Draw
- San Carlos River
- Silver Creek
- Sycamore Creek
- Williamson Valley Wash
- San Pedro River (Cienegas los Fresnos and la Cienegita, Sonora, Mexico)
- Bass, Hot Springs, and Double R canyons
- Bonita Creek
- Dix Creek
- Harden Cienega Creek (Arizona)
- Little Sycamore Creek
- Lousy Canyon (stock from Silver Creek)
- Redfield Canyon
- Sabino Canyon
- Sheehy Spring
- Spring Creek
- Walker Creek

Table 16. Continued.

Location	Location Description	Present (last observed)	Most recent collection/ Lit. Reference	Population Status
Garden Canyon, Cochise County	San Pedro River drainage, stocked by AGFD from Turkey Creek (n=150).	No (1988)	AGFD 1995 monitoring	Extirpated
Harden Cienega Creek, Greenlee County	San Francisco River tributary.	Yes (1995)	P. Marsh, ASU (pers. comm.)	Unknown
Indian Creek, Yavapai County	Agua Fria River drainage (Langhorst 1995).	Yes (1995)	Langhorst (1995)	Unstable-Threatened
Larry Creek, Yavapai County	Agua Fria River drainage, stocked by BLM in 1995 from Silver Creek.	Yes (1995)	Langhorst (1995)	Unknown
Little Sycamore Creek, Yavapai County	Agua Fria River drainage.	Yes (1995)	AGFD 1995 monitoring	Unstable-Threatened
Lousy Canyon, Yavapai County	Agua Fria River drainage, stocked by AGFD/BLM in 1995 from Silver Creek.	Yes (1995)	Langhorst (1995)	Unknown
Monkey Spring/Sonoita Creek, Santa Cruz County	Santa Cruz River drainage, extirpated by largemouth bass introduction (Minckley 1973).	No (1968)	DeMarais (1986), Minckley (1973)	Extirpated
O'Donnell Creek, Santa Cruz County	San Pedro River drainage.	Yes (1995)	AGFD 1995 monitoring	Stable-Threatened
Post Canyon, Santa Cruz County	Upper San Pedro River drainage, tributary to O'Donnell Creek.	No (1989)	AGFD 1995 monitoring	Extirpated
Queen and Arnett Creek, Pinal County	Gila River drainage, possibly introduced from Salt River (see discussion).	No (1938,1945)	USFS, Tonto NF surveys	Extirpated
Redfield Canyon, Graham and Pima Counties	San Pedro River drainage.	Yes (1994)	TNC 1991-1994 monitoring	Stable-Threatened
Red Tank Draw, Yavapai County	Verde River Drainage	Yes (1995)	AGFD 1995 surveys	Unknown
Sabino Canyon, Pima County	Santa Cruz River drainage.	Yes (1994)	Dudley (1995)	Unstable-Threatened

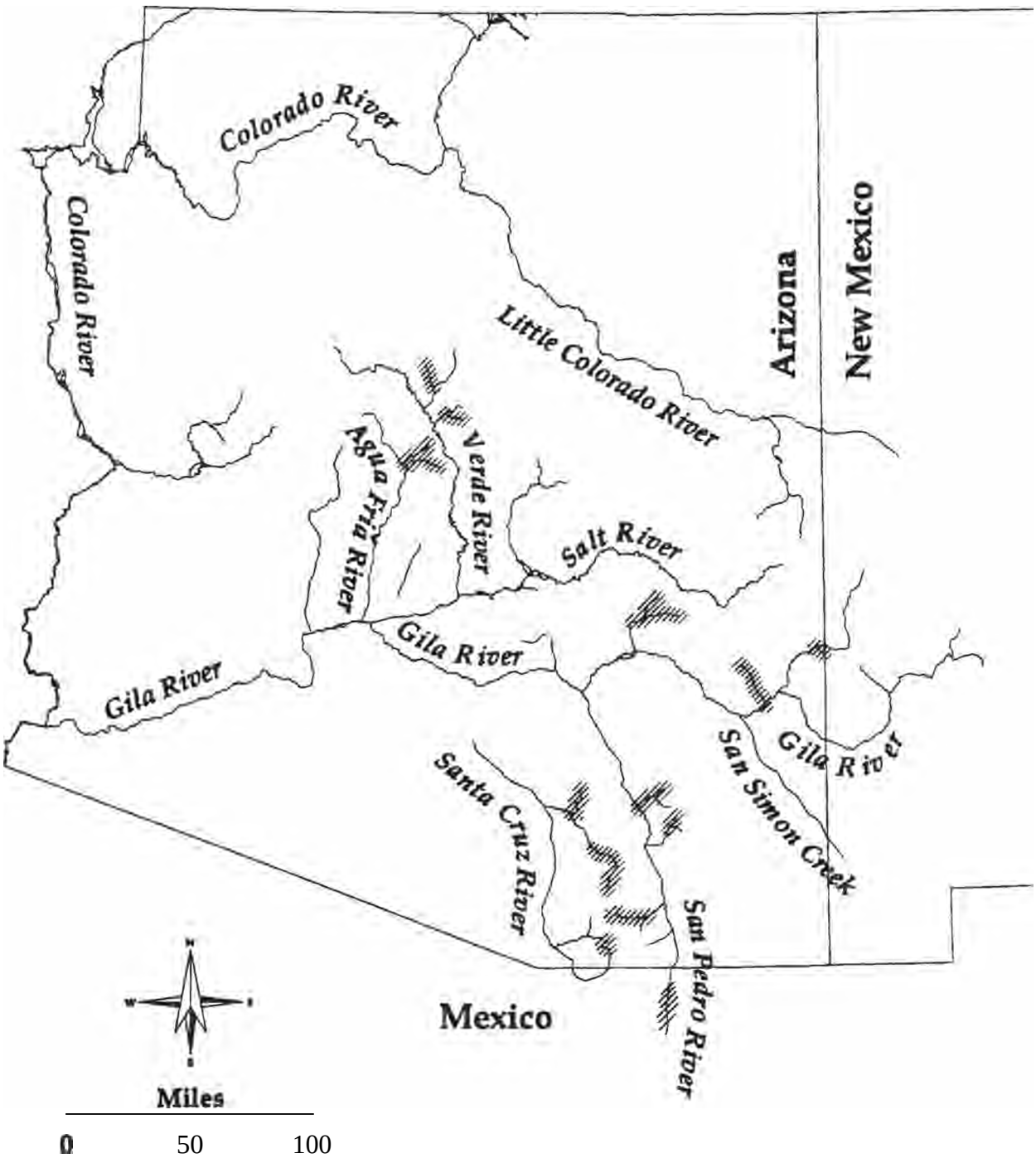

Figure 2. Present known distribution of the Gila chub.

populations include loss of habitat due to water diversion and ground water pumping for irrigation and municipal uses, dam and reservoir construction, increased peak flood discharges, sedimentation resulting from land management practices, and negative interactions with competitive and predatory nonnative fishes, especially green sunfish. Present distribution and abundance are also reflections of surface water declines contributed by lowering of water tables and draining of marshes and cienegas by arroyo cutting (Hastings 1959; Miller 1961; Hastings and Turner 1965; Minckley and Deacon 1968; Rinne 1976; Hendrickson and Minckley 1984).

As of June 1995, Safford, Arizona was considering petitioning the Arizona State Department of Water Resources for additional water extraction rights to Bonita Creek. This could directly affect the existing Gila chub population. Bureau of Land Management currently has a "reserved water right" from Congress for unallocated water in Bonita Creek (Jeff Simms, BLM, pers. comm.). The future of instream flows in Bonita Creek is threatened, at best.

The introduction of predatory and competitive nonnative fishes such as red shiner, fathead minnow, channel catfish, flathead catfish, mosquitofish, green sunfish, largemouth bass, and smallmouth bass also pose a threat to Gila chub survival (Hubbs 1955; Miller 1961; Minckley and Deacon 1968; Rinne and Minckley 1970; Naiman and Soltz 1981; Meffe 1985; Williams and Sada 1985; AGFD 1988; Rime and Minckley 1991; Dunsmoor 1993; Ruppert et al. 1993). Dudley (1995) correlated green sunfish presence with Gila chub declines in Sabino Creek, Arizona. This included predation by small green sunfish on young-of-year Gila chub. Minckley et al. (1977) suggested that predation by green sunfish may explain the absence of Gila chub from the upper Santa Cruz River. Additionally, parasites introduced incidentally with nonnative species may jeopardize Gila chub populations (USFWS 1983). Gila chubs in the lower portion of Bonita Creek, Arizona, appear to be adversely affected by *Lemaea* spp. (Civish 1994).

Natural environmental or climatological factors also may be impacting Gila chub populations. Seasonal fluctuations in the extent of available surface flow, associated stagnation effects of drying streams, and increasing water temperatures may negatively affect Gila chub populations (Stout et al. 1970; Rinne 1975; Carpenter 1992; Dudley 1995), especially when combined with anthropogenic impacts and the current restricted distribution of the species. Documentation of such events can be correlated to changes in other western cyprinid populations (Miller 1963; Minckley and Carufel 1967).

SPECIES STATUS

Twenty four populations of Gila chubs exist. Of these, 9 are of unknown status (2 were recently established and survival is still uncertain), 6 are considered unstable and threatened, 8 are considered stable but threatened, and 1 is considered stable and secure. Many of the factors contributing to the number of threatened populations are the result of human-induced factors, including introduction of nonnative fishes and limited habitat due to human use or manipulation of surface and sub-surface water resources.

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Appendix C. Stream-specific summary of Gila chub collections. Reference identification numbers indicate museum records and field collections that are referenced on the Land Ownership Maps. Reference identification letters refer to museum records and field collections that are not referenced on the Land Ownership Maps. Species code abbreviations were defined in Appendix A.

Table C-1. Indian Creek, Yavapai County, Arizona.

Reference Id.	Date	Source	Collector	Descriptive Location	Legal location	Latitude Longitude	Other Species
49.	950516	AGFD NFDB FFC FC0170	Langhorst	Indian Creek	11N 3E Sec. 25 SE4 SW4	341747 1115943	AGCH PACL

Table C-2. Silver Creek, Yavapai County, Arizona.

Reference Id.	Date	Source	Collector	Descriptive Location	Legal Location	Latitude Longitude	Other Species
A.	800710	ASU 10251	Silvey		10N 3E Sec. 10		
B.	800709	ASU 10288	AGFD		ION 3E Sec. 10		
C.	800709	ASU 10291-10292	AGFD		10N 3E Sec. 9		
71	920908	AGFD NFDB RHBOO1	Bettaso, Weedman		10N 4E Sec. 7 SE4 SW4	341523, 1115823	None
74	921008	AGFD NFDB FFC FC0160	Hughes, Langhorst	Road crossing N of Bloody Basin /Double Tank Rd.	10N 3E Sec. 11 SE4	341529, 1120027	AGCH PIPR LECY PACL
72	931013	AGFD NFDB FFC FC0160	Hughes, Langhorst		10N 3E Sec. 11 SE4	341529, 1120027	AGCH PIPR PACL LECY
73	941027	AGFD NFDB FFC FC0160	Hughes, Langhorst		ION 3E Sec. 11 SE4	341529, 1120027	None reported
88.	941104	AGFD NFDB FFC FC0160	Hughes Langhorst		ION 3E Sec. 9 SE4 SE4	341512, 1120222	AGCH PIPR PACL LECY

Table C-4. Little Sycamore Creek, Yavapai County, Arizona.

Reference Id.	Date	Source	Collector	Descriptive Location	Legal location	Latitude Longitude	Other Species
A.	800821	ASU 10007	Dahlberg	Little Sycamore Creek, Sta. 1	11N 4.5E Sec. 6		PACL AGCH RHOS
B.	800821	ASU 12082	Nowakowski	Little Sycamore Creek, Sta. 2	11N 4E Sec. 5		PACL AGCH RHOS
50.	950427	AGFD NFDB DBD001	Dorum	Little Sycamore Creek, above Horner Mountain Ranch	11N 4E Sec. 4 SE4 NE4	342145 1115613	AGCH PACL
51.	950427	AGFD NFDB DBD001	Dorum	Little Sycamore Creek, Reno Canyon Confluence	11N 4E Sec. 5 NW4 SE4	342142 1115725	AGCH PACL

Table C-5. Cave Creek and Seven Springs Wash, Maricopa County, Arizona.

Reference Id.	Date	Source	Collector	Descriptive Location	Legal location	Latitude Longitude	Other Species
A.	500601	UMMZ 162839 listed as GIRO	Miller, Winn	Cave Creek, 4 mi N of town of Cave Creek			RHOS
B.	500601	UMMZ 162841 listed as GIRO	Miller, Winn	Seven Springs, @ USFS campground, 20 mi NNE of town of Cave Creek			RHOS
C.	650907	ASU 2162-2164 listed as GIRO	Johnson	Cave Creek at 7 Springs picnic area			
D.	690000	ASU 4453	Stout	at Seven Springs			RHOS AGCH
E.	700318	ASU 4923, ASU 4929	Rinker, Anderson	Seven Springs, upper section, in ditch @ head spring			AGCH RHOS
F.	780222	ASU 7764	Clarkson	Cave Creek, at campground			

Table C-10. Spring Creek, Yavapai County, Arizona.

Reference Id.	Date	Source	Collector	Descriptive Location	Legal location	Other Species
A	**830606**	**ASU 10374-10378**	DeMarais	N/A		
B	**830616**	**ASU 10384-10387**	DeMarais	N/A		
82.	**790825**	**AGFD**	Clarkson Grayson	at **3560'** elevation	**16N 4E** Sec. **22 NE4 SW4**	**PACL** RHOS **MIDO** CAIN **AGCH**
83.	**850612**	**ASU 10458**	DeMarais	N/A	**16N 4E** Sec. **22**	
	940802	**AGFD NFDB** JTR001	**AGFD** Region **2**	downstream from Forest Road **796**	**16N 4E** Sec. **22 SW4 SW4**	**PACL** RHOS CAIN
	950906	**AGFD NFDB** DAW001	**Weedman**	downstream from Forest Road **796**	**16N 4E** Sec. **22**	**AGCH** CAIN **PACL PIPR** RHOS

Table C-11. Williamson Valley Wash and Big Chino Wash, Yavapai County, Arizona. There was

Reference Id.	Date	Source	Collector	Descriptive Location	Legal location	Other Species
A	**(18)970313**	**SMNH 48121,** reported as **GIROIN**	Gilbert	Chino, Arizona (Big Chino Wash)		**MEFU** RHOS **TICO**
B	**500530**	**UMMZ 162834**	Not available	Big Chino Wash, ca. **2 mi** SE of **K4** farm	19N **4W** Sec. **23 NE4**	CAIN
107	**920516 920517**	**AGFD NFDB** RHB001	**Bettaso** Anderson	Williamson Valley Wash	**T17N R3W** Sec. **30 NW4**	

Table C-14. Blue River, Gila County, Arizona.

Reference Id.	Date	Source	Collector	Descriptive Location	Legal location	Latitude Longitude	Other Species
A.	500512	UMMZ 162757	Miller, Winn	30 mi NE of Globe			PACL
B.	680419	ASU 4444 MSB 3414	Anderson	7 mi E of Cassodore spring			
D.	740613	ASU 6746, 11310	Kobetich	1 mile above crossing above falls			
E.	830516	ASU 11199	Marsh				
F.	830516	ASU 10485	Minckley				
G.	850523	ASU 11615	Minckley, Parkin	at Blue River Camp	2N 19E Sec.17		
12.	721202	ASU 6226	McNatt	crossing with Indian Route 5			
	880921	AGFD NFDB DAH002	Hendrickson	crossing with Indian Road #5	2N 20E	333037 1101646	PACL

Table C-16 Cienega Creek, Pima and Santa Cruz counties, Arizona.

Reference Id.	Date	Source	Collector	Descriptive Location	Legal location	Latitude Longitude	Other Species
A.	690000	UA 69-79-1		10 mi N of Sonoita	19S 17E		
B.	740427	ASU 6279	Minckley	at Cienega Ranch			
C.	740518	ASU 6747	Minckley	at Cienega Ranch			
D.	740628	ASU 6859	Minckley	at Cienega Ranch			
E.	760604	ASU 6860-6861	Kepner Landye	at Cienega Ranch			
F.	820317	UMMZ 209808	Belfit Meffe	confluence with Stevenson's Creek elevation 4200'	18S 17E sec. 23 NE4		
G.	830606	ASU 11519, ASU 11959	Meffe	at Ranch			
H.	830606	ASU 10364-10373	DeMarais				
27.	850731	AGFD NFDB JEB002	Brooks			314930 1103410	AGCH POOC
28.	890724	AGFD NFDB BEB002	Bagley		18S 17E Sec. 35, NW4 NW4	314950 1103508	None
29.	890724	AGFD NFDB BEB004	Bagley		19S 17E Sec. 10, SE4 SE4	314730 1103515	AGCH POOC
30.	920618	AGFD NFDB DAW001	Weedman		18S 18E Sec. 6, SW4	315325 1103247	AGCH POOC
31.	921027	AGFD NFDB FFC FC0315	Not recorded		18S 17E Sec. 13 N1/2 N1/2	315230 1103345	AGCH POOC
32.	921031	AGFD NFDB FFC FC0313	BLM	Between Oak Tree Canyon and Empire Gulch	19S 17E Sec. 3, NE4 SE4	314833 1103522	AGCH POOC

Table C-17. Sabino Canyon, Pima County, Arizona.

Reference Id.	Date	Source	Collector	Descriptive Location	Legal location	Latitude Longitude	Other Species
A.	1966	UA 66-118-1	Not available	Lower Sabino Creek			
B.	290422	SMNH 94272	Kranzther				
C.	380906	UMMZ 125043 listed as GIRO	Hubbs et al.	16 mi NE. of Tucson, above picnic grounds			AGCH
D.	430418	UMMZ 146651	Simon	15 mi NE. of Tucson			GAAF POOC
E.	430619	UMMZ 146688	Simon	0.5 mi above end of road			
F.	490926	UA (Lowe's)	Not available				
G.	801022	ASU 8450	Hendrickson Minckley				
69.	901029	AGFD NFDB FFC FC0370	Not available	Sabino Canyon Recreation Area Between Bridges 8 & 9		322000 1104722	
67.	921109	AGFD NFDB FFC FC0350	Weedman	Sabino Canyon Recreation Area, multiple locations, see map			GAAF LECY
68.	930603	AGFD NFDB FFC BPD001	Denova	Sabino Canyon Recreation Area, multiple locations, see map			LECY
80.	940111	AGFD NFDB FFC FC0350	Lopez, Weedman	Sabino Canyon Recreation Area, multiple locations, see map			LECY
81.	941018	AGFD NFDB FFC FC0350	Lopez	Sabino Canyon Recreation Area, multiple locations, see map			LECY

Table C-19. Sheehy Spring, Santa Cruz County, Arizona.

Reference Id.	Date	Source	Collector	Descriptive Location	Legal location	Other Species
70	390412	UMMZ 131103 listed as GIRO	Ashburn Gorsuch	"Shehe" Springs, San Rafael Valley, 0.5 mi from Santa Cruz River	22S 17E Sec. 3 (probably wrong)	AMME POOC
70	400906	SMNH 118423, 118424 listed as GIROIN	Ashburn	Santa Cruz River, 2 mi NE of Lochiel and at "Sheyhe" Spring		
70	500419	UMMZ 162671 listed as GIRO	Miller Winn	"Sheke" (Sheehy) Springs, 6 mi NE of "Sochcel" (Lochiel?)		
70	770316	ASU 8464	Johnson Rinne			
70	780401	ASU 7823	Minckley			
70	781114	ASU 8458	Landye Rinne			
70	801004	ASU 11472	Milstead			
70	891027	AGFD NFDB FFC OFC091	Stefferud & Stefferud	Sheehy Spring	24S 17E Sec. 11 NW4 NW4	GAAF
70	911026	AGFD NFDB FFC FC0830	Stefferud & Stefferud	Sheehy Spring	24S 17E Sec. 11 NE4	GAAF
70	930810	AGFD NFDB DAW001	Weedman	Sheehy Spring	24S 17E	GAAF

Table C-21. Continued.

Reference Id.	Date	Source	Collector	Descriptive Location	Legal location	Latitude Longitude	Other Species
[illegible]	920000 930000	AGFD NFDB TNC Annual Monitoring RDCRP1	Gori	Redfield Canyon, randomly sampled pool	11 S 20E Sec. 32		AGCH CAIN
[illegible]	920000 930000	AGFD NFDB TNC Annual Monitoring RDCRP2	Gori	Redfield Canyon, randomly sampled pool	11 S 20E Sec. 32		CAIN LECY
[illegible]	920000	AGFD NFDB TNC Annual Monitoring RDCRP3	Gori	Redfield Canyon, randomly sampled pool	11 S 20E Sec. 32		CAIN
[illegible]	920000	AGFD NFDB TNC Annual Monitoring RDCRP4	Gori	Redfield Canyon, randomly sampled pool	11 S 20E Sec. 32		CAIN LECY RHOS
[illegible]	920000	AGFD NFDB TNC Annual Monitoring RDCRP5	Gori	Redfield Canyon, randomly sampled pool	11 S 20E Sec. 32		AGCH CAIN PACL RHOS
[illegible]	920000	AGFD NFDB TNC Annual Monitoring RDCRP6	Gori	Redfield Canyon, randomly sampled pool	11 S 20E Sec. 32		CAIN RHOS
58	891203 902101	AGFD NFDB FFC OFC441, FC4420	Not available	Redfield Canyon, above stone ranch house	11S 19E Sec. 35 SW4 NW4 SW4	322557 1102255	AGCH CAIN LECY PACL RHOS
59.□	881009	AGFD NFDB FFC OFC441	Not available	Redfield Canyon, 7 mi upstream of Redington	11S19E Sec. 35 SW4	322555 1102242	AGCH CAIN LECY PACL PIPR RHOS

Table C-22. Bass, Hot Springs, and Double R canyons, Graham and Cochise counties, Arizona.

Reference Id.	Date	Source	Collector	Descriptive Location	Legal location	Latitude Longitude	Other Species
A.	770623	ASU 7454	Thompson	Bass Canyon,	12S 21E Sec. 31		PACL RHOS
96.	800520	ASU 8454	Mills	Bass Canyon, at 4050' elevation	12S 21E Sec. 31		
B.	891026	AGFD NFDB FFC OFC451	Gori	Bass Canyon, below Pattersons Cabin	12S 21E Sec. 31		AGCH CAIN MISA PACL RHOS
C.	930000 940000	AGFD NFDB TNC Annual Monitoring BASRP1	Gori	Bass Canyon, randomly sampled pool	12S 20E		AGCH CAIN PACL RHOS
D.	920000	AGFD NFDB TNC Annual Monitoring BASRP2	Gori	Bass Canyon, randomly sampled pool	12S 20E		AGCH CAIN PACL RHOS
E.	920000 930000 940000	AGFD NFDB TNC Annual Monitoring BASRP3	Gori	Bass Canyon, randomly sampled pool	12S 20E		AGCH CAIN PACL RHOS
F.	940000	AGFD NFDB TNC Annual Monitoring BASRP4	Gori	Bass Canyon, randomly sampled pool	12S 20E		CAIN PACL
G.	920000 940000	AGFD NFDB TNC Annual Monitoring BASRP5	Gori	Bass Canyon, randomly sampled pool	12S 20E		AGCH CAIN PACL RHOS
H.	930000	AGFD NFDB TNC Annual Monitoring BASRP6	Gori	Bass Canyon. randomly sampled pool	12S 20E		AGCH PACL

Table C-22. Continued.

Reference Id.	Date	Source	Collector	Descriptive Location	Legal location	Latitude Longitude	Other Species
9.	910000 920000 930000 940000	AGFD NFDB TNC Annual Monitoring BAS006	Gori	Bass Canyon	12S 21E Sec. 31 NE4 NW4	322107 1101440	AGCH CAIN PACL RHOS
10.	910000 940000	AGFD NFDB TNC Annual Monitoring BAS007	Gori	Bass Canyon	12S 21E Sec. 31 NW4 NW4	322100 1101450	AGCH CAIN PACL RHOS
11.	910000 930000 940000	AGFD NFDB TNC Annual Monitoring BAS008	Gori	Bass Canyon	12S 20E Sec. 36 SE4 NE4	322054 1101512	AGCH CAIN PACL RHOS
43.	930000	AGFD NFDB TNC Annual Monitoring DRC003	Gori	Double R Creek	12S 21E Sec. 31 NE4 NE4	321412 1102112	AGCH RHOS
44.	940000	AGFD NFDB TNC Annual Monitoring DRC001	Gori	Double R Creek	12S 21E Sec. 30 NW4 NE4	321428 1102200	AGCH PACL RHOS
45.	910000	AGFD NFDB TNC Annual Monitoring HSC002	Gori	Hot Springs Creek	12S 20E Sec. 25 SW4 SW4	322116 1101550	AGCH CAIN PACL RHOS
46.	930000	AGFD NFDB TNC Annual Monitoring HSC001	Gori	Hot Springs Creek	12S 20E Sec. 25 SE4 SW4	322116 1101535	AGCH CAIN PACL RHOS

Table C-24. O'Donnell Canyon, Santa Cruz County, Arizona.

Reference Id.	Date	Source	Collector	Descriptive Location	Legal location	Latitude Longitude	Other Species
A.	781117	ASU 8461	Johnson	O'Donnell Creek at TNC Ranch			
B.	830608	ASU 10349-10352	DeMarais	O'Donnell Creek			
85.	770504	AGFD Files	O'Brien Ginnelly	O'Donnell Creek, 1/4 mile stretch of USFS land between TNC property	T21S RI8E Sec. 33 NE4 of NW4		AGCH CAIN
	890726	AGFD NFDB BEB005	Bagley	O'Donnell Canyon	21S 18E Sec. 28 SW4 SE4	313423 1103115	
52.	920617	AGFD NFDB DAW003	Weedman	O'Donnell Canyon	same as above	same	LECY
	930811	AGFD NFDB DAW002	Weedman	O'Donnell Canyon	same as above	same	LECY AGCH
53.	910000 920000 940000	AGFD NFDB TNC Monitoring ODC001	Gori	O'Donnell Canyon	21S 18E Sec. 33 NW4 SW4	313350 1103138	CAIN LECY AGCH
54.	910000 940000	AGFD NFDB TNC Monitoring ODC002	Gori	O'Donnell Canyon	21S 18E Sec. 33 NE4 NW4	313408 1103125	AGCH CAIN LECY
55.	910000 940000	AGFD NFDB TNC Monitoring ODC003	Gori	O'Donnell Canyon	21S 18E Sec. 33 NE4 NW4	313415 1103119	AGCH CAIN LECY
56.	910000 940000	AGFD NFDB TNC Monitoring ODC004	Gori	O'Donnell Canyon	21S 18E Sec. 28 SE4 SW4	313420 1103115	LECY CAIN
57.	890726	AGFD NFDB BEB003	Bagley	Post Canyon	21S 18E Sec. 28 SW4 NW4	313450 1103134	
86.	950828	AGFD NFDB DAW002	Weedman	O'Donnell Canyon	21S 18E Sec. 28 NE4 SW4 SE4		
87.	950829	AGFD NFDB DAW002	Weedman	O'Donnell Canyon	21S 18E Sec. 33 NW4		CAIN LECY

Table C-26. Bonita Creek, Graham County, Arizona.

Reference Id.	Date	Source	Collector	Descriptive Location	Legal location	Latitude Longitude	Other Species
A.	500502	UMMZ 162710 listed as GIRO	Miller Winn	near confluence with Gila River			PACL CAIN AGCH TICO RHOS
93.	690629	ASU 4690	Rinne	at Bear Canyon NW of Ranch			PACL CAIN AGCH RHOS
15.	770624	ASU 7218	Minckley	at 3650' elevation	5S 27E Sec. 23 N1/2		
99.	780204	ASU 7742	Clarkson	at 3810' elevation	5S 27E Sec. 3 SE4		AGCH
97.	780204	ASU 7738	Clarkson	at 3690' elevation	5S 27E Sec. 14 S1/2		AGCH CAIN PACL
94.	780326	ASU 7851	AGFD	at 3250' elevation			CAIN PACL AGCH CYLU RHOS PIPR
21.	780421	ASU 7886	Clarkson	at 3760' elevation	5S 27E Sec. 14 N1/2 N1/2		CAIN PACL AGCH
26.	780421	ASU 7883	Clarkson	at 3840' elevation	5S 27E Sec. 3 N1/2		PACL AGCH
98.	780804	ASU 7984	Clarkson	at 3700' elevation	5S 27E Sec. 14 S1/2		CAIN PACL
J	830517	ASU 10411-10415	DeMarais	Bonita Creek			
K	851015	ASU 10531	Brooks	lower backwater			
13.	931209	AGFD NFDB JRS001	Simms	Bonita Creek	5S 27E Sec. 23 SE4	325847 1093230	AGCH CAIN PACL RHOS
14.	931209	AGFD NFDB JRS002	Simms	Bonita Creek	5S 27E Sec. 23 Center	325856 1093245	AGCH CAIN PACL RHOS

Table C-27. Eagle Creek, Graham and Greenlee counties, Arizona.

Reference Id.	Date	Source	Collector	Descriptive Location	Legal location	Other Species
A.	340727	UMMZ 216958 listed as GIRO	Madsen	Eagle Creek, 100 yds. Above Honey Moon Ranch		
B.	390300	UMMZ 131126 listed as intergrade	Gorsuch	East Eagle Creek, N of Clifton		
C.	500508	UMMZ 162745 listed as intergrade	Miller et al.	3.4 to 4 mi S of Eagle Ranger Station, in Box Canyon	5S 29E Sec. 31 NW4 NE4	PACL CAIN AGCH RHOS TICO
D.	500508	UMMZ 162744, 162746 (listed as GIRO)	Miller et al.	3.4 to 4 mi S of Eagle Ranger Station, in Box Canyon	5S 29E Sec. 31 NW4 NE4	PACL CAIN AGCH RHOS TICO
E.		DeMarais (1986)		Uncatalogued specimens		
79.	780326	ASU 7836	Clarkson	Honeymoon Campground at 5400' elevation	2N 28E Sec. 31 NE4 SE4	